No. 6880

DEC 2 1957

JOHN T. FEY, Clerk

United States Court of Appeals

FOR THE THIRD CIRCUIT

Appeals Nos. 12216 and 12217

THE COLD METAL PRODUCTS COMPANY,

Plaintiff, Appellant,

v.

CRUCIBLE STEEL COMPANY OF AMERICA,

Defendant, Appellant.

APPENDIX TO CRUCIBLE'S BRIEF

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OPENING STATEMENT FOR PLAINTIFF

[4] Mr. Webb: For the subsequent period, that is, from November 30, 1951, to April 1, 1953, it paid nothing at all, on the theory that it had modified the mill to some extent, and that the mill was outside the scope of the patents in that period.

Now, we don't contend that Crucible is liable for [5] any royalties in that particular period, unless one or more of the claims of one or more of the licensed patents covered the mill, or its operation, during that period.

* * *

WILLIAM R. HOWELL (WORKS MANAGER OF CRUCIBLE'S MIDLAND PLANT)

[213] *Direct Examination by Mr. Webb:*

Q. Mr. Howell, were you in on the discussions leading to the modification of the pinch roll setup on your 4-high reversing mill? A. I was in several of them.

Q. And would you give me the sequence of events, was it decided that you were going to try to get away from the payment of royalties by modifying your pinch roll structure, and then you started out thereafter to find some way of modification; was that the sequence? A. Mr. Webb, I think you will remember a clause in the agreement between Crucible and Cold Metal which identified one of the basic patents, upon the expiration of which the royalties were to be cut 50 per cent. There is another sentence in that paragraph which reads that Crucible will only be liable insofar as the mill has jurisdiction over several of the claims in the remaining patents. That was [214] enough of a challenge to us to explore the matter very thoroughly with our oper-

ating, engineering and counsel. That was the sequence which led up to the changes.

Q. So that the way in which I have stated it was correct; namely, that in the top level management, of which you are a part, the decision was reached to try and avoid the patents and then ways and means were sought through the operating or engineering personnel to try to avoid the patents, is that correct? A. I don't know whether the choice of words as you use them—avoid the patents—was the correct thing. I have shown that your agreement stated, and it was understood by both parties, that insofar as the mill to which we are referring operated under the jurisdiction of the patents royalties were chargeable. But if it didn't operate under the claims of the patents, royalties were not payable.

Mr. Webb: Now, will you read my question?

The Court: He thinks the word "avoid" has a sinister connotation.

Mr. Webb: Will you please read my question?

The Court: If he said "evade" the patent, I think then it would have the sinister connotation which Mr. Howell has in mind.

Mr. Webb: Yes.

The Court: Avoidance isn't usually bad in the [215] law, it is evasion that is bad.

Mr. Webb: I wonder if you would read the question to Mr. Howell. I don't believe he answered it at all. We have no quarrel in regards to the terms of the agreement, Mr. Howell. The agreement speaks for itself. So you don't need to tell us what is in the agreement. We can read. But I would appreciate it if you will try to answer this question.

Mr. Walker: I think Mr. Howell would appreciate it if you wouldn't attempt to tell him what he thought, but ask him to phrase himself how he thought.

(Question read.)

A. Yes.

* * *

[217] *Cross-Examination by Mr. Walker:*

Q. I am going to read a sentence from Section 3, Paragraph 8 of the agreement between the parties and ask you if this is the sentence that you had in mind and referred to in your answer to Mr. Webb a few minutes ago. It reads: "It is understood and agreed, however, that the royalty payments specified herein are to continue only so long as Crucible's mills and equipment or operations are covered by unexpired claims of the Cold Metal patent, and this irrespective of the duration of this agreement." Is that the sentence you had in mind? A. Yes.

* * *

WILLIAM BRUCE LOCKWOOD (COLD METAL'S PRESIDENT)

[225] *Direct Examination by Mr. Webb:*

Q. Does the Cold Metal Products Company manufacture any hot roll strip? A. No, we have no hot roll strip manufacturing facilities.

* * *

[264] *Cross Examination by Mr. Walker:*

Q. Is it true, Mr. Lockwood, that at the present time there is no one in the United States who is paying royalties to your company for the operation of a reversing hot strip mill? A. I think that is correct.

Q. And there are operating in the United States at the present time the following reversing hot strip mills, in addition to the one in issue in this case: first, there is such a mill at the McLouth Steel's Livernois Avenue plant? A. Yes.

Q. That was a mill that was originally operated under license under certain patents from your company? A. Yes.

Q. And the McLouth Company was held by the Circuit Court of Appeals for the Sixth Circuit to be not required to pay royalties for the operation of that mill from and after 1940? [265] A. I know there was a certain date, I don't recall that definitely, but I know there was a certain date.

Q. That date was the date on which you made your settlement agreement with U. S. Steel? A. I don't recall.

Mr. Webb: We will agree that that is correct, Mr. Walker.

Mr. Walker: About the end of August, 1940?

Mr. Webb: August 30, 1940.

Mr. Walker: Yes.

Q. And then another such reversing hot strip mill that is being operated in this country without royalty to you is that of the Newport Steel Company? A. Yes.

Q. Which was the subject of the recent decision of the Sixth Circuit Court of Appeals holding invalid the only three patents that were charged to be infringed? A. Did you mention a patent number?

Q. I didn't mention a patent number, I said three patents. A. That is correct.

Q. The only three patents that were charged to be infringed were held to be invalid, is that right? A. Yes.

Q. Then there is a mill of the Byers Company, against which you have a suit pending, but which has never taken a [266] license or paid you any royalties? A. Yes.

Q. Then there is a mill in Texas of the Lone Star Steel Company against which you have made an informal claim, but against which you have not brought suit and which has not paid royalties? A. Yes.

Q. Does that exhaust the list of reversing hot strip mills in this country, so far as you know them? A. I think that is the complete list.

Q. Where is Mr. Montgomery these days? A. I think he is in California.

Mr. Webb: Mr. Walker, you evidently omitted from your list the McLouth Trenton Mill, with which I am sure you are familiar, since that is involved in litigation.

Mr. Walker: No, I didn't omit it, Mr. Webb. I was speaking as of the present time, and my information is that the mill is no longer either in operation or in this country.

Mr. Webb: I am sorry, the mill was taken out recently, that is correct.

Mr. Walker: I will supplement the questions.

Q. There was, until comparatively recently, another reversing hot strip mill in this country, namely that of the McLouth Steel Company at its Trenton plant? A. Yes.

[267] Q. That mill was operated without license from your company and is the subject of litigation between your

company and McLouth, which is presently awaiting decision before judge Levin in Detroit? A. Yes.

Q. That mill—that was brought, incidentally, as a declaratory judgment suit by McLouth against your company? A. It may have been, I don't definitely recall that that was the character of the suit.

Q. I can assure you that it was because I brought it. A. Well, I wouldn't doubt it.

Q. And involved in that suit are charges of infringement by your company by that mill of McLouth of some six patents? A. Yes.

Q. Including the three patents here in suit? A. I will take your word for it but I don't definitely remember.

Q. And the Steckel '214 patent? A. Again I can't remember.

Q. And the Keeney & Ferm patent? A. I presume that is correct, but again I cannot definitely remember.

Mr. Webb: I will agree that is correct.

Mr. Walker. And there is one other I can't recall what it is. It is another Montgomery patent.

[268] Mr. Webb: Montgomery '121 patent.

Mr. Walker: Montgomery '121. That's all.

* * *

RALPH A. FREED (COLD METAL ENGINEER)

[412] *Cross Examination by Mr. Walker:*

Q. Do you happen to have any illustration, Mr. Freed, of the reversing coiling hot mill on which you worked at the [413] Briar Hill Works of the Youngstown Sheet & Tube Company? A. Do we have any drawings of it, you mean?

Q. Any illustration of it? I think possibly if you don't this one will serve. I will have to ask you about that.

Does this drawing that I show you illustrate schematically, at least, the reversing coiling hot mill which you worked on at the Briar Hill Works? A. Yes, very close schematically.

Mr. Walker: I will ask that that be marked Exhibit D-1.

(Received in evidence and marked Exhibit D-1.)

* * *

[420] Q. In the Crucible mill the work is apportioned between just two millstands, the finishing reversing stand and the roughing mill, in direct accordance with the Steckel suggestion? A. That is correct.

Q. Are you sufficiently familiar with the continuous hot mills that were in commercial use in the area in 1930 to [421] 1935 to tell us whether or not it was conventional in such mills to have roughing mills in line with the finishing mill connected by a roll table so that the material was first rough rolled in the roughing mill and then fed on into the finishing mill and there finished at the same heat? A. That was true; a typical installation of that was the so-called Butler mill.

Q. Yes. But in about 1926? A. I don't know the date.

Q. Consisting of a roughing part of the mill with one or more roughing mills and a finishing part of the mill, consisting of, I think, four in that case, finishing stands, perhaps five, perhaps six? A. That is true.

* * *

[427] When you operated that mill at Briar Hill was the coiling reel drive of such a character as to impose tension on the strip between the coiling reel and the mill proper? A. Yes.

Q. Was the rotation of the unwinding reel retarded in some way so as to impose back tension on the strip between the unwinding reel and the mill? A. It was, yes.

* * *

[430] Q. What, if any, difference or distinction do you draw between front and back tension as it exists in the Briar Hill mill or in the Crucible mill and that referred to in Steckel patent 670, tab 1 of Exhibit D-2, where Steckel says, beginning line 56, "Each coiler is motor driven and may be operated at such a rate as to maintain the delivered strip under tension"? A. I don't get the meaning of your question.

[431] Q. Well, you are familiar with Steckel patent 670, are you not? A. Yes, I am.

Q. Do you have a copy of it there? A. No, I don't happen to have a copy of 670.

Q. I will give you a copy of the binder, Exhibit D-2. The patent is at tab 1. It shows a reversing hot strip mill involving coilers in furnaces on each side of the mill stand, doesn't it? A. Yes, sir.

Q. So there is no doubt that strip is hot as distinguished from the cold strip you were discussing a moment ago? A. Yes, sir.

Q. Now look at page 1, Column 2, beginning line 56, where the patent says, "Each coiler is motor driven and may be operated at such a rate as to maintain the delivered strip under tension." And my question to you is: What, if any, distinction do you draw between that kind of tension and that kind of tension which you said exists in the Briar Hill mill and you have said exists in the Crucible mill? A. I would say it was the same.

Q. Did the Briar Hill mill have at the entrance to its coiler furnaces a roll located in a position corresponding to

that occupied by what you have been calling the [432] deflector roll in the Crucible mill; namely, in such a position as to protect the strip from being drawn against the bottom of the furnace? A. Yes, sir; it did.

Q. In that mill what function was performed by that deflector roll? Did you call it a deflector roll there? A. Primarily that was installed to, purely and simply, protect the strip from coming up against the metal, or sharp corners in that. But then after we had it in operation a while we discovered, inadvertently, that it was causing us something else that was very beneficial, especially on your low carbon steel. We noticed that there was considerable of scale would be down on the table in under that roll. So that we found it was playing a very important part in that steel, that as the secondary scale would be forming, as it was flexed around there, and wound up, it was causing that secondary scale to crack and a lot of it would fall off.

So immediately we felt that that was a very good feature because it assisted in keeping the surface of the strip better, and protected the roll. So immediately we called it a scale breaker roll, which is the name that we have referred to it for years.

Q. Is there any significance to the fact that in [433] describing that roll in the Crucible mill you call it a deflector roll whereas for years you have called it a scale breaker roll? A. I have no knowledge why the name was changed, unless it just would be the engineering department, down at United, when they designed the mill, the man that designed that particular part put that name down on it as a deflector. Other than that I wouldn't know.

Q. How about your own terminology, in your own circles, do you still refer to it as a scale breaker roll? A. I always do, yes, because that is the one name that I am more familiar with than anything else.

Q. You haven't heard any discussions, or participated in any discussion, to the effect that now that Steckel patent 214 has expired it would be better to call it by some other name? A. I have not, no.

* * *

[458] Q. I am going to be questioning you, Mr. Freed, with reference, if you care to follow in the patent, with reference to claim 6 of Patent 107, and I am going to ask you to look at D-1 and each clause of the claim, tell me whether that is descriptive of the apparatus shown in this mill, Exhibit D-1. Does D-1 involve a method of rolling strip? [459] A. It does.

Q. And does it include the steps of passing a breakdown, heated to plastic condition, back and forth between reducing rolls? A. It does.

Q. Uncoiling it on one side and coiling it on the opposite side of the rolls? A. That's correct.

Q. Passing an end of the breakdown entirely through the rolls? A. That's correct.

Q. Frictionally gripping said end to feed it back through the rolls? A. Correct.

Q. That frictional gripping is by the pinch roll on the entry side? A. That's right.

Q. And then does D-1 involve freeing that portion of the breakdown between the mill and the point of coiling? A. Yes.

Q. What happens to free it, in D-1? A. The pinch rolls on that side would be lifted up off of its pinch position.

Q. Was that the operation at Briar Hill? A. After the strip was in the furnace and started to coil [460] in there it was lifted up on the delivery side, yes.

Q. Do you mean the delivery side or the entry side? A. Well, the side between the mill and the coiler.

Q. Well, let's go back and get a starting place here. A. All right.

Q. Frictionally gripping said end that has been passed entirely between the rolls to feed it back through the rolls. That is the pinch rolls on what is at the moment the entry side? A. That's right.

Q. Now, in the Briar Hill installation, after that action had been performed, did the pinch rolls remain closed or were they opened up so as to free that portion of the breakdown between the mill and the point of coiling? A. On the original Briar Hill mill, I am not certain just what that operation was of those pinch rolls, just when they were raised.

Q. Now, what about the pinch rolls on the delivery side in the operation that we are examining, did they stay closed and serve to feed the leading end of the strip up into the opposite coiler—— A. They did.

Q. —or were they apart? [461] A. In the first rolling they were kept down to feed the end of the strip up into the coiler.

Q. Did they stay in the pinch position throughout that pass or was the upper pinch roll retracted so as to free that portion of the breakdown between the mill and the point of coiling? A. I am not positive—the Briar Hill installation—as to when they were lifted up off of the strip.

Q. And then the concluding phrase of the claim, "and tensioning such portion uniformly throughout," did that occur in the Briar Hill mill? A. It did, yes.

Q. On both sides of the mill, that is to say, between the mill and the coiling reel and the mill and the uncoiling reel? A. We had difficulty in maintaining it, but we tried to, and our result was to tension it by either slowing or increasing the speed of those coiling reels.

Q. Now, in that mill, in such instances as the pinch rolls were retracted, or either of the pinch rolls was retracted, during a coiling operation, were they retracted far enough to free the breakdown between the mill and the coiler, or uncoiler, as the case may be? A. If they were retracted, they would be far enough to free it, yes.

[462] Q. So that there was this difference between that operation that you have just described and the operation of the original Crucible mill; namely, that when the pinch rolls of the Crucible mill were retracted to low lift position they weren't freed from the strip, but, on the contrary, bore down on the strip and assured that it would be maintained at a level below the level of the upper flanges of the side guides? A. Yes, those pinch rolls kept the strip down in that position.

Q. And that is in contrast to the action described in connection with Exhibit D-1, where the retraction of the pinch rolls was such as to free them from the strip? A. If and when the pinch rolls were lifted off of them they would be considerably higher than your Crucible mill.

Q. Now, in the Crucible original installation, with the pinch rolls in low lift position, was the upper pinch roll driven? A. In the Crucible mill?

Q. Yes. A. Yes, sir.

Q. In synchronism with the table rolls? A. Yes, sir.

Q. So that if the drive was perfect, perfectly synchronized, the contact between that pinch roll and the [463] strip would not interfere with the uniform tensioning of the strip all the way from the mill rolls to the winding reel, or the unwinding reel, as the case might be? A. If everything was in perfect condition, perfectly synchronized, that would be pretty much the truth, yes.

Q. Now let's compare that with the situation in the Crucible mill as presently operated. There the thing relied

upon to hold the strip down, below the level of the upper flanges of the side guides, is the hold-down or auxiliary roll, as distinguished from the pinch roll, is that right? A. Yes, sir.

Q. And that auxiliary or hold-down roll in the present Crucible mill is not driven, is it? A. No, sir.

Q. So that to whatever extent the driving of an otherwise undriven roll by the strip itself serves to create any inequality of tension in the strip between the mill and the coiling or uncoiling reel, such inequality is present in the Crucible mill as presently operated, isn't it? A. If it is, you would never be able to measure it, it would be so slight.

* * *

[469] Q. What kind of side guides did the mill have at Briar Hill? A. We tried out four or five or six different types of side guides on that mill, endeavoring to get a set that we would consider would be satisfactory.

Q. Did you have in use at all side guides like those in Stecker Patent 214? The best picture of them, I think, is at Fig. 6 of that patent. It is the tab 3 of Exhibit D-2. A. Yes, we tried them.

Q. Was it true of those guides that they were set closer together on the entry side and further apart on the exit side? A. As I recall, yes.

Q. Indeed, that has been true of all the side guides you have ever used on these mills, hasn't it? The entry guides are closer together, almost touching the edges of the strip and the guides on the exit side are opened up a little to prevent jamming as the end of the strip comes through the mill? A. Yes, sir.

Q. And it has always been necessary, hasn't it, in these mills to reverse the positioning of those guides when the

direction of travel of the strip through the mill is changed? A. That is necessary.

Q. It has always been true, you have always had to do it, [470] right? A. Yes, sir.

Q. Is the particular guides of this Steckel Patent 214, wasn't it so that the reversal of positions of the side guides, so that they would be close together on what was going to be the entry side and further apart on what was going to be the exit side, was accomplished automatically when the direction of travel of the strip was changed? A. The position of the guides was governed by the direction in which the table rolls were going, that friction would either cause them, by linkage, to open up or close in.

Q. So the operator didn't have to think about it at all, he just did whatever he had to do to dictate to the motor which direction it should run in, and then start it in that direction? A. Reversed his mill table.

Q. And the guides took care of themselves and went into the appropriate position by reason of the frictional contact they had with the table rolls? A. That is right.

Q. Now, would you look at and keep in mind those Steckel side guides as I read you claim 10 of Patent 122 in suit, and tell me, as I pause after each clause of the claim, whether or not the Steckel side guides and arrangement are described by the claim "The combination with a rolling mill [471] having a driving motor and a controller for the motor"—Steckel 214 had that, didn't it? A. Yes, sir.

Q. "—of adjustable side guides on both sides of the mill"—? A. Yes, sir.

Q. "—and means operated by said controller for shifting the guides inwardly on the entrance side of the mill and outwardly on the exit side of the mill—"? A. There was no control directly connected to the side guides; it was merely as you reversed the mill, reversed the table, the

frictional resistance on there would cause them to go in or out, but there was no separate drive to your guides.

Q. Well, the table rolls were, themselves, the means for moving the guides inward on one side and outward on the other side of the mill? A. Yes, sir.

Q. And those means, the table rolls, were under the control of the motor controller, weren't they? A. Right.

Q. Now, you apparently have in mind some possible distinction between that kind of an arrangement and what there is in the Crucible mill, do you? A. I have none.

Q. So that claim is equally applicable, just as applicable [472] to Steckel 214 as it is to Crucible? A. Except that Crucible has a positive drive to your side guides, where this does not.

Q. Positive as distinguished from frictional, you mean? A. Yes, sir.

Q. You are not thinking about separate electrical connections, are you? A. They are set up down there where it can be manual or controlled with the mill, on your Crucible.

Q. What is it in the Crucible mill that causes the side guides to reverse their position into positions appropriate for travel of the strip in the different directions? A. Now when he reverses his mill, his controller, through his electric hoo[illegible]p, will cause the motor to revolve and either cause the side guides to go in or come out, according to the direction on which side of the mill it is.

Q. You have looked at the operator's instrument pa[illegible]l and control desk down at Crucible? A. I have.

Q. There are two such panels? A. Yes.

Q. One is known as the operator's panel and the other known as the assistant operator's panel? A. That's right.

* * *

[473] Q. How is the Crucible mill stopped at the end of a pass during the coiling operation? A. He centers his control.

Q. Who does? A. I am not sure in your operation down there whether it is such setup where it is all controlled by the one man or whether both men can stop the mill, depending upon the direction. I am not sure of that setup.

Q. Well, there is a motor controller on the operator's desk, isn't there? A. Yes.

Q. Is there one on the assistant operator's desk? A. I am not positive whether there is or not, no.

Q. Which of the two men stops the mill? A. I do not know.

Q. What action of what man is it which actuates the side guides in the Crucible mill? A. It should be the man that reverses the mill.

Q. Well, is it? A. I don't know.

Q. What movement of what switch causes the side guides to reverse their position in Crucible mill? A. Now or——

[474] Q. Now? A. —or when it is set up manually?

Q. Now. A. The only control that I would know would be the one that controls the direction of the mill, other than that I wouldn't know.

Q. Has your experience been more mechanical or electrical, or has it been part of each? A. It is by far more mechanical than electrical.

Q. See these two lights on Judge Modarelli's bench? A. Yes, sir.

Q. You see the little switches, a switch on each light, so that one can, if he wishes, turn them on or off independently? A. Yes, sir.

Q. Would you consider that it would require any great ingenuity to so wire the lights that the pushing of a single switch will light both lights? A. No, sir.

Q. Do you see anything different in principle between that and so wiring up a rolling mill that when you change the direction the side guides are changed? A. It is not a difficult job, no, sir.

Q. It calls for no more than routine engineering? A. That's right.

* * * *

[477] Newark, N. J.

Thursday March 29, 1956

(TRIAL RESUMED PURSUANT TO ADJOURNMENT)

RALPH A. FREED, resumed the stand.

The Witness: Your Honor, I would like to have your permission to make some comments on some of the testimony that I gave yesterday.

The Court: Well, is it in the nature of correction of testimony?

The Witness: It is, sir. After last night —

The Court: You answered my question. You want to correct your testimony.

The Witness: I do, sir.

Mr. Walker: It is the first I heard of it. Of course, I want the witness' testimony to be something he vouches for. It is up to your Honor how you will handle it. I suppose if he is going to do it anyway, it would be better for him to do it now than on redirect.

The Court: Yes. I think it is more practical to do it now than to wait and then go all through it again.

[478] This is the first time I have had such a request. I have had people who wanted to correct their testimony before Grand Juries. I have never had it in the trial of a cause, Mr. Freed. We do want your honest opinion. We want the truth as you know it. So you may correct it now, subject to any objection that Mr. Walker may make, if he thinks one is in order.

The Witness: Last night, when I read over the transcript of the testimony I gave yesterday, I noticed that there were several of the answers that I gave to some of the questions that put the wrong interpretation on the operation of the experimental hot mill out at Brier Hill Steel, and I thought it was advisable to get that cleared up as soon as possible.

Of course, I was not present at all the demonstrations, or all the rollings, and everything, that was done on there. So what I would like to give is that part of it that I know I saw and actually worked with.

The Court: I was under the impression that you were only telling us that, anyway.

The Witness: I was, to the best of my ability; yes, sir.

The Court: All right.

[479] On Page 127 of App. 7b]

The Court: You gentlemen watch it because I don't have my copy here.

The Witness: The first question that Mr. Walker asked, as shown on that page

"When you operated that mill at Briar Hill was the coiling reel drive of such a character as to impose tension on the strip between the coiling reel and the mill proper?".

My answer was, "Yes."

In fact, that could not have been possible on that mill because during all the rolling, where any coiling was taking place, we kept the pinch rolls down on the strip. It was not released during the rolling process. Therefore, that would impose a pressure between the mill and the coiling reel so that the tension would vary between the mill and the pinch rolls and the pinch rolls and the coiling reel.

The second question was:

"Was the rotation of the unwinding reel retarded someway so as to impose back tension on the strip between the unwinding reel and the mill?"

My answer was: "It was, yes."

The Court: Is that the same page?

The Witness: The same thing applies there, that pinch roll—

The Court: On the same page?

[480] The Witness: The same page, yes, sir.

The Court: What was that page?

The Witness: 427a. [App. 8b]

Mr. Walker: Would your Honor like a copy?

The Court: I have it now, thank you.

The Witness: The same thing applied there, the pinch rolls being in a pinch position on the strip would not permit tension direct from the mill to the coiling reel but would break it up between the two.

On Page 431a [App. 8b] down almost to the bottom of the page, where the long question comes in

"Now look at page 1, Column 2, beginning line 56, where the patent says, 'Each coiler is motor driven and may be operated at such a rate as to maintain the delivered strip under tension.' And my question to you is: What, if any, distinction do you draw between the kind of tension——"

Mr. Walker: That kind of tension.

Mr. Webb: That kind of tension.

The Witness: "—that kind of tension which you said exists in the Briar Hill mill and you have said exists in the Crucible mill?"

The point there is, as I explained in the other questions, the Briar Hill mill has the pinch rolls on the strip which breaks up the tension between the reel and the mill, while on the Crucible mill the pinch rolls, or the [481] hold-down, is released so the tension is uniform, direct from the reel to the mill or from the mill to the reel. It is just a little different type.

Then on page 459, [App. 10b] about the third question up from the bottom of the page, Mr. Walker asked:

"And then does D-1—" that is the big chart here that shows the Briar Hill mill— "then does D-1 involve freeing that portion of the breakdown between the mill and the point of coiling?"

Again the pinch-rolls are down on the strip and held there in that place.

The next question:

"What happens to free it, in D-1?"

The answer was: "The pinch rolls on that side would be lifted up out of its pinch position."

Well, in fact they were not lifted up off, and I just want to clarify that they were kept on during all of that time.

On page 460 and 461, [App. 10b-12b] I won't read those questions and answers, but it all applies to the same principle as to whether the pinch roll goes down. So as to make it clear, all during the rolling of the strip where it was being coiled in the furnaces, the pinch roll was being kept in contact with the strip at all times during the rolling there at Briar Hill Steel, as far as I have any knowledge of it.

[482] I think that is the extent of the comments I wish to make, sir.

The Court: All right, sir.

Cross-Examination (Continued) by Mr. Walker:

Q. When did you for the first time observe any mill operation in which the pinch rolls were retracted so as to free the strip after the pinch rolls had served their function of feeding the strip into either the mill or a coiling reel? A. It would either be Dominion or McLouth; I don't recall now just which of those two plants I saw in operation first, because they were both coming along at practically the same time, but it would be either one or the other.

Q. Would you state what that time was, as accurately as you can? A. I would say it was in late '35 or early '36.

[483] Now, I would like to understand a little more fully than I do what you mean when you say that the pinch rolls engaging the strip between the mill and the point of coiling, or uncoiling, broke up the tension. I think that was your phrase. A. If you had a coiling reel that is overrunning, or running just a little faster than the mill, and there was nothing to interrupt it in between, it would exert uni

form tension from the reel to the mill. But if in the meantime you put a pair of pinch rolls, or anything pressing down very severely on the middle of that strip between the mill and the reel you would have considerable different tension, as we noticed out there at Briar Hill, because occasionally, if things were not being just absolutely a hundred per cent synchronized, the reel would feed off just a little faster than the mill could be taking it away, and being held there by the pinch rolls it would have a tendency to want to fold up, and loop, and get wavy between the reel and the pinch rolls, while it would still be tight between the pinch rolls and the mill. That was one of the conditions we had to try to overcome.

Q. Perhaps this will help develop the point. I show you Steckel patent 670, which is at Tab 1 of Exhibit D-2. There a mill is shown, and a coiling reel in a furnace on each side. [484] A. Yes, sir.

Q. And is it not your understanding that those coiling reels were so driven so as to maintain tension upon the strip between the mill and the winding reel, and the mill and the unwinding reel? A. I wouldn't know what his thought was in those early stages, but you would have to—if the reels are driven there would have to be at least tension between the winding reel and the mill.

Q. Well, I call your attention to that part of the text beginning at page 1, Column 2, line 56, reading, "Each coiler is motor driven and may be operated at such a rate as to maintain the delivered strip under tension."

Doesn't that mean to you, when taken in conjunction with the fact that the strip between the two reels and the mill touches nothing whatever in the way of either pinch rolls, or deflector rolls, or anything else, that the strip on each side of that mill is maintained under uniform tension?

A. It would not necessarily be under uniform tension, because the pressure exerted on those rolls would interfere with the tension that is set up by the coiling reel.

Q. I am sorry. I don't follow you. I thought you said a moment ago that it was the interposition of the pinch rolls on the Briar Hill mill that broke up the tension [485] and that if the strip from the mill to the coiling reel, for example, was not in contact with any roll then the tension imposed by the winding reel would be uniform all the way from the coiling reel to the mill. That is what you said, isn't it? A. Yes, from the coiling reel to the mill.

Q. Yes. Now, isn't this Steckel patent 670 a perfect example of that kind of situation, the strip not being in contact with anything all the way from the mill to the coiling reel? A. Now you are considering the tension just between the reel and the mill.

Q. That's right. A. Yes, sir.

Q. That's uniform all the way, because the strip touches nothing and there is nothing to alter the tension, to make the tension be different at any one point as compared with any other point in that length of strip? A. No, sir.

Q. You mean you agree with me? A. Yes.

Q. Then between the mill and the uncoiling reel is not the situation the same, that it is under tension if the coiler is driven in such a way as to put it under tension and that tension is uniform in the strip all the [486] way from the unwinding reel to the mill? A. That is true.

Q. And indeed it was one of the features of the claims of that patent, the last phrase of Claim 2, "maintaining the metal under tension between the rolling thereof and the coiling thereof." A. I don't know anything about it. I am not familiar with that.

Q. Now, starting with the understanding—and I will confine this, for simplicity, to the delivery side of the mill

where the reel is serving as a winding reel—if we have the strip untouched by anything from the mill to the coiling reel, and the coiling reel is driven so as to impose tension, it necessarily follows that that tension will be uniform all the way from the coiling reel to the mill. Are you with me so far? A. Yes, sir.

Q. Now, if we interpose or put in contact with the strip on its way from the mill to the coiling reel a roll such as the deflector roll and we drive that deflector roll by an external source of power at precisely the speed at which the strip is moving, then that deflector roll will not break up in any way the uniformity of tension which existed before the roll was put there. Do you agree with that? [487] A. Yes, sir.

Q. If, on the other hand, that same deflector roll is not provided with an external source of power but requires for its driving force some force transmitted to it by the passing strip then it would interfere with the uniformity of tension and result in a tension on one side of the deflector roll being one value and on the other side of the deflector roll a different value, is that right? A. I doubt if I could 'theoretical enough to go into such a fine point, because it would be so infinitesimally small, if it did exist, that to any practical purpose and extent I certainly wouldn't be able to state whether it did or did not, it would be so slight.

Q. Then would it be your view that anyone who claimed that it was a measurable advantage to put a drive on an existing deflector roll like that was exaggerating the situation, to say the least? A. I wouldn't know, except they might think it would be highly advisable.

Q. Well, I don't follow you.

The Court: Do you see any advantage to be gained by that deflector roll tension, sir?

The Witness: The tension—no, sir; none.

The Court: Well, that is what Mr. Walker is [488] trying to find out, isn't it?

Mr. Walker: I think it is clear. He says that maybe there is a theoretical advantage to driving it, but it is so small that you can't measure it. And I guess we were at that point yesterday. But I am using this merely as a transition to consider what the effect is of the pinch rolls being interposed.

* * *

[503] Q. I am going to shift now the discussion to the Crucible mill after the changes, which involves the same pair of pinch rolls, but now equipped to have only a high lift or up position 12 inches off the strip and at the bottom no position other than a complete pinch position. You have that in mind, do you? A. I do.

Q. All right. When that pinch roll of the Crucible mill is dropped on to the strip, it drops the full 12 inches, doesn't it? A. It does; yes, sir.

Q. As distinguished from the one and a half inches [504] that it dropped when it went into the pinch position on the original mill? A. That's correct.

Q. So that as presently constructed the Crucible mill does not enjoy the advantage that you attributed to having a high lift and low lift position that when the pinch roll dropped on to the strip to go into the pinch position it didn't have to fall that great distance and hit the strip, and dent it, and maybe even break the bearings, is that right?

* * *

[505] A. On the Crucible mill the hydraulic cylinder that operates the raising and the lowering of that pinch roll is a Logan cylinder, made by the Logan Manufacturing Com-

pany, and it has what they call cushions on both ends. So it is a standard type of cylinder, so that you get your full, quick stroke down so far and then your main port is closed, and then there is only a very little, itty-bitty bit of a port that can be adjusted, that lets the air out slowly for a short space, so that it comes down close, like that, and then the rest of the distance.

Now, that cylinder that they use can be so adjusted to come down and cushion it so it would not give that terrific impact to the dropping of the 12 inches.

Q. I guess perhaps I will have to break it up, since you haven't answered it. Is this true, Mr. Freed, that one of the important advantages that you claimed for the provision of a low lift position as distinguished from just a high position and a pinch position for the pinch rolls was that when you dropped the pinch roll all the way from a full retraction on to the strip you dented [506] the strip, and banged the rolls, and sometimes even broke the bearings of the table roll? A. That is true of the original experimental mill at Briar Hill-Steel; we found that condition did exist; yes, sir.

Q. And it was to get rid of that, that was one of the main purposes of putting in this low lift position, right? A. Yes, sir; it was.

Q. And with that low lift of only an inch and a half you found that when you dropped the pinch roll from that low lift position on to the strip that you didn't have that trouble of denting and breaking? A. No, we eliminated considerable of that. And then we also found that we gained a lot of other advantages that were unlooked for.

* * *

[507] Q. Now, insofar as that particular advantage, having a shorter travel so as not to have such an impact

when the pinch roll was closed to the pinch position, Crucible's present arrangement doesn't take advantage of that particular feature, does it? A. They take advantage of it in a little different way, by cushioning that cylinder so that it only comes down with full force so far, and the last little portion of the cylinder it is slowed down to get away from that impact. That is a standard type cylinder.

Q. But the descent that the roll makes is the 12-inch full travel that you were trying to get away from in providing a low lift position? [508] A. The total stroke is, yes.

Q. Now, you said that this cushioning effect in this hydraulic cylinder, and you volunteered the name of the supplier—as a matter of fact, it isn't even a hydraulic cylinder, is it; it is an air cylinder? A. Air cylinder.

Q. Yes. Now, another advantage that you mentioned as flowing from the provision of a low lift position was that being a shorter stroke it didn't consume as much time to make the travel, is that right? A. That is true.

Q. Now, so far as that advantage of a high lift-low lift position is concerned, does the Crucible mill as presently designed and operated enjoy that advantage? A. No, under the present setup they do not.

Q. They still have to take the time to make the full 12-inch travel. Now, another advantage that you attributed to that high lift-low lift arrangement of Montgomery's that I had in mind was that by reason of the counteraction of the cylinders for the full travel and the cylinder, or cylinders, for the short travel, there was a sort of cushioning effect involving the entrapment of part of the air, and so on, is that right? A. When which cylinder was operating when? I don't just——

[509] Q. Well, you tell me. Didn't you claim that there was some cushioning effect present in the Montgomery high lift-low lift arrangement when the pinch roll was in

the low lift position? The question at the moment is, did you tell me that, did you state that in your testimony? A. Yes, I believe I did.

Q. And the thing that you were talking about can be seen in Fig. 6 of the patent, Patent 122. That's at Tab 5. A. That's, in general, the arrangement of the lifting cylinders, yes.

Q. And the cylinders at each end are the long stroke cylinders—— A. That's true.

Q. —provided to give the high lift position? A. Yes, sir.

Q. And the cylinders just inside of those outer cylinders, the short ones, marked 82, are the cylinders and pistons provided to give the low lift position, is that right? A. That's true.

Q. And would you explain how this cushioning effect which is present in the Montgomery low lift position is achieved? A. If you will turn to our drawing No. 7, that shows the [510] pinch roll operation, it is much easier explained, because it is colored and very recognizable.

The Court: That is in the plaintiff's drawings?

The Witness: Yes.

Mr. Walker: That's right. It is drawing No. 7 of their set.

The Witness: Now, your Honor, I went through this all very carefully yesterday.

The Court: I know you did yesterday.

The Witness: Now I suppose I should go through it again for him.

Q. Well, you don't need to, if you will follow my question and answer it. I have already asked you if it wasn't so and you went off the subject. Isn't it so, that the cushioning action in the low lift position of Montgomery is

achieved by reason of the fact that air cylinders are used and that the air in the large cylinders is imprisoned and consequently serves as a sort of flexible or yieldable buffer that makes that cushioning effect? A. That is true.

Q. Yes. Now, in the Crucible mill the roll which you said corresponded to the low lift position of Montgomery is the hold-down roll, isn't it? A. That is so called, a hold-down roll, yes.

[511] Q. And that is in a position three inches above the strip instead of an inch and a half as the predecessor low lift position was? A. That is right.

Q. And that hold-down roll of Crucible's present mill doesn't have any such cushioning action as the Montgomery low lift pinch roll had, does it? A. Not to as great an extent as an air cylinder; no, sir.

Q. It doesn't have any cushioning effect because it has got a hydraulic cylinder and hydraulic fluid is incompressible, isn't it? A. Not a hundred per cent. There is always some air trapped in that. But that also could be accomplished by the piping or valving arrangements of the fluid up to that, which I am not familiar with.

Q. Are you asserting that there is a cushioning effect present in the Crucible hold-down roll comparable to the cushioning effect that was present in the Montgomery low lift pinch roll position? A. I say it is possible to do so, if they so desired, yes.

* * *

[523] I will shift to Patent 065, which is at Tab 6 of the binder, Exhibit D-2. I want to ask you about a phrase in Claim 5 of that patent, line 51, starting really at 50, where it speaks of "feeding the thinned body to a reversing mill after cropping at least one end of the thinned body to facilitate its entry into said reversing mill." What is that

action that is referred to there? A. When the slab or the original body they are starting to roll has been rolled down to a thin enough gauge that they want to send it down to the finishing mill, quite frequently the ends, or the nose on it are fishtailed, or split, or some [524] defect on it, and they like to crop off the ends, preferably both ends, so as to assist in the piece entering the mill, and then to the pinch rolls and entering into the coiler.

Q. That act of cropping, then, consists of merely operating a shear to cut off either or both ends of the strip, if they have been deformed sufficiently to lead the operator to think they might make trouble if they were continued, allowed to remain on the strip? A. It is generally a policy to cut them off at all times if they are so equipped to do so.

Q. You say that is the policy. Do you mean at the Crucible mill, or do you mean mills generally? A. Mills, generally, although I have seen it done at Crucible.

Q. What is the shear in the Montgomery patent? Is it labeled? A. Which patent is that, sir?

Q. This is 065 that we are talking about. I think I found it in the text, the shear is the thing marked 13. A. 13, I think, that is right.

Q. It says, page 1, column 2, line 6, "A slab shear 13 is positioned at a suitable distance ahead of the mill 11 with a connecting roll table 14 therebetween." Now, you say that this act of cropping by means of a shear is general practice in rolling mills generally? A. It is quite frequently used, yes.

[525] Q. Did the Butler mill that you referred to yesterday have a cropping shear? A. Where?

Q. Anywhere? A. They had to have a crop shear when they rolled the ingot to a slab and cropped the slab in that process.

Q. Did they have any cropping shear that operated on the slab or any thinner piece of material produced from the slab on the way down to the final hot roll gauge? A. I don't recall that they did.

Q. It would be surprising if they didn't, wouldn't it? A. Not necessarily.

Q. You must have seen how many continuous hot mills? A. Half a dozen, possibly.

Q. Did you ever see one that didn't have a cropping shear someplace in fairly near proximity to the beginning of the finishing part of the mill? A. No, it is my recollection it is a general, accepted, good practice.

Q. And has been for how many years? A. For quite a number of years.

* * *

Recross Examination by Mr. Walker:

[547] Q. You remember on redirect examination Mr. Webb asked you a question about the statement in the text at page 1, Column 2, line 60, or line 59, where Steckel said, "I provide a mill which is relatively simple and compact in construction employing preferably but a single reducing stand, although it may in certain instances be desirable to divide the work between two stands."

Do you have the patent in mind, and that statement about which you answered questions on redirect? A. I had no patents in mind, I was just giving my own interpretation to a question, but——

Q. Now, Mr. Webb asked you—unless my memory is playing tricks on me—if there was any teaching in this patent as to how the work would be divided between two stands if one decided to follow the suggestion made by Steckel in this passage that I have just read. Didn't you

have such a question asked you and didn't you give an answer that you didn't find any teaching as to where you would divide it? A. I didn't recall that a reference was made as to this particular patent. I was putting it in the wording as he read it to me with—the understanding was that—did that wording, as he read it to me, definitely specify as to how the work should be divided, and my answer was that I [548] had no knowledge, or wouldn't know what his intent was as to how to divide the work. That is all.

[549] Q. Now, doesn't this patent disclose an operation in which part of the rolling is done in the flat, without the use of the coiling furnaces? A. Yes, sir.

Q. And it discloses another kind of rolling which does involve the use of the coiling furnaces, right? A. That is right.

Q. And the deflectors are down when you want to do flat rolling, and they are up when you want to do coiling rolling, is that right? A. That is right.

Q. Now, to do coiling rolling you have to have rather unusual equipment in the form of coilers in furnaces, don't you? A. You do.

Q. To do flat rolling you don't need any such appurtenances, do you? A. No, sir.

Q. Wouldn't you think it logical for anyone who had decided to follow this suggestion of Steckel to divide the work between two stands to divide it in such a way that the coiling rolling would be done in the mill that had coilers, and that the flat rolling would be done on some other millstand that didn't have coilers? A. If you had a mill setup in front of you and was told to [550] operate it and one mill did not have coilers and the other one did, you certainly would have to divide your work so as to do the coiling on the mill that had the coilers.

Q. Suppose you didn't have anything but a single stand reversing mill with coilers and you decided to follow Steckel's suggestion that instead of doing the whole job on that mill you would divide the work between two stands. Wouldn't you think it would be logical to put in an additional mill that didn't have coilers and do the flat rolling on it and do the coiling rolling on the mill that had the coilers? A. I would.

Q. A perfectly logical, straightforward way of dividing the work between two stands, if you were going to follow the suggestion, right? Have you answered? A. No, I didn't hear any question.

Mr. Webb: I would like to have the question read. I don't think he realized there was a question, you dropped your voice so.

(Question read by the reporter.)

A. That certainly would be a good way to do it.

* * *

GEORGE SACHS (COLD METAL EXPERT).

[583] *Cross Examination by Mr. Walker*:

Q. I am going to put up here Exhibit D-1. Do you recognize the relationship that exists between that chart and the Steckel '214 patent? A. That's correct, yes.

Q. I would like to check with you to see to what [584] extent the functions you attributed to the pinch rolls of the original Crucible installation are performed by the pinch rolls of that patent.

The first function that you attributed to the pinch rolls of the original Crucible installation when in their pinch posi-

tion was to feed the strip into the mill. That function was performed in the Steckel '214 patent, wasn't it?

The Witness: Can you repeat the question?

(Question read.)

A. Yes.

Q. The second function of the pinch rolls in the pinch position in the Crucible original installation that you spoke of was to pull the strip off the uncoiling reeler; that's right, isn't it? A. Yes.

Q. The pinch rolls of the Steckel '214 patent perform that function, don't they? A. Yes.

Q. Now, what additional function, if any, did the pinch rolls in the Crucible original installation perform when they were in the pinch position? A. Well, they performed that stopping function, too, and——

Q. All right. Let's speak of that. [585] A. And they also——

Q. Just a minute, doctor.

Mr. Webb: Let him finish.

Q. You have spoken of the stopping function. I want to discuss it. Don't the pinch rolls in the Steckel '214 patent perform that same stopping function that you attributed to the pinch position of the original Crucible installation? A. That's correct.

Q. Are there any other functions that the pinch rolls in the pinch position performed—— A. Yes, as far as——

Q. —in the original Crucible mill?

The Witness: Will you repeat the question?

The Court: You better wait till he finishes the question.

The Witness: Yes, sir.

(Question read.)

The Witness: Can you repeat that again?

(Question read.)

A. Well, I don't get that. We are talking about the Steckel patent '214 now, and there are, of course, other functions in the Steckel patent. Now you are switching your question completely to the Crucible mill now?

Q. I am not switching them at all. I have been [586] asking you right along about the functions performed by the pinch rolls in the Crucible mill, which was the first subject covered in your direct examination.

Now, you have listed three functions which they performed in the pinch position in the Crucible mill, original mill. Are there any other functions that you haven't mentioned yet? A. Well, I can't follow you, Mr. Walker. You asked me which additional functions the pinch roll performs in the Steckel patent. Now, I have never answered that question to its end.

Q. I have not asked you that. I have asked you if there are any functions performed by the pinch rolls of the original Crucible mill other than the three functions you have already listed in that connection? A. Well, now, coming to the Crucible mill—of course, I said already I have never seen the Crucible mill in operation in its original setup, so in that sense I can't answer your question. But from the drawings, and from whatever I can see, the original Crucible mill performs—would perform these same three functions in exactly the same way, by substantially the same means, and with the same effect or result as the modified installation does.

* * *

[621] Q. Now, as of May 25, 1955, you have had no experience whatever with reversing hot mills; that is right, isn't it? A. Prior to May, 1955?

The Court: You had no reversing hot mill experience?

The Witness: No practical experience, that is correct, yes.

Q. Well, had you had any impractical experience? A. Well, I have been engaged in the McLouth case as an expert and made a study, and of course studied on paper the operation of the McLouth mill in very considerable detail.

* * *

WILLIAM H. COLVIN (CRUCIBLE'S PRESIDENT 1945-1954).

[637] *Direct Examination by Mr. Walker*:

Q. Did you give consideration, along with the other management personnel of Crucible, to the installation of any other type of mill than the reversing hot strip mill that was put in? A. Yes, sir; there is—shall I answer? I thought I heard an interruption.

Q. Well, you did give consideration to another type? A. Yes, sir.

Q. What type was that? A. There are two types; one is a straight continuous mill, continuous in the breakdown and continuous in the finish, and another is a reversing breakdown and continuous in the finish.

Q. Were you personally familiar to any extent with the type of mill that you have referred to as a continuous mill? A. Yes, sir.

[638] Q. What mills of that type were you aware of? A. The first that was ever built, at Butler, Pennsylvania.

The people who organized Rotary Electric Steel Company in Detroit were the creators of that mill. That's Naugle & Townsend.

Q. You were familiar then with that particular mill, were you? A. Through them; yes, sir.

Q. Have you seen any other continuous mills? A. Yes, sir.

Q. You might mention a few that come to mind. A. The first mill installed at Great Lakes was in existence when I moved to Detroit, and the mill at Weirton was functioning.

Q. Will you describe very briefly what the rolling process was that was practiced in those continuous mills? A. Yes, sir; they both dealt only in carbon steels. The mill at Great Lakes and the mill at Weirton were both continuous in the breakdown as well as continuous in the finishing.

Q. Were they continuous between the breakdown and the finishing stage? A. There was a substantial gap between the end of the roughing train and the beginning of the finishing train.

Q. They were arranged in line with one another, [639] were they? A. Throughout the mill; yes, sir.

* * *

[642] Q. And when you reached the decision to put in a reversing hot coiling strip mill, did you give any consideration to the patent situation relating to such a mill? A. Oh, very definitely, yes. That came naturally because [643] of my friendship with Mr. McLouth, who had had difficulty with his patent situation up there of considerable magnitude.

Q. When you say difficulty I take it you refer to litigation? A. Yes, sir.

Q. With Cold Metal? A. That is difficulty to me.

Q. You reached a conclusion, I take it, to take a license from Cold Metal, is that right? A. Yes, for two reasons we reached that.

* * *

[645] Q. Did you ever know a man named Robert M. Keeney of Midland, Pennsylvania? A. I knew of him. He died before I came.

Q. You knew him? A. Yes.

Q. Who was he? A. He was ultimately president of the Pittsburgh Crucible Company, a wholly-owned subsidiary, operating in Midland, Pennsylvania.

Q. Did you know a man named John F. Ferm? A. Very well. He was our chief engineer while I was with the company at Midland.

Q. You signed on behalf of Crucible Steel Company of America the license agreement between that company and Cold Metal which was entered into on September 30, 1946? A. I will have to ask you to look and see. I probably did.

> Mr. Webb: We will agree that Mr. Colvin is the one who signed it. It is this Mr. Colvin.
>
> The Witness: If it says W. H. Colvin, Jr., that's I.

Q. Section 11 of this agreement says, "At any time after March 1, 1953, Crucible shall have the right to cancel [646] this agreement upon giving Cold Metal 30 days advance notice in writing of its intention to cancel."

Can you tell me in what manner the date, March 1, 1953, included in that section, was arrived at?

* * *

[648] The Court: Do you know of your own knowledge, sir, how you arrived at that date?

The Witness: I know from the reports read to me by our general counsel, who negotiated with Mr. Webb.

The Court: Well, I am sure Mr. Webb will verify them, if your counsel gave you the correct information, and if he didn't I am sure Mr. Webb will correct him.

So what did your general counsel tell you how you agreed on that date?

The Witness: I have to start before that. The [649] general counsel was instructed, in so far as he was able, to give a cancellation privilege to Crucible to cancel the agreement at the expiration of the Keeney & Ferm patent. Patent counsel for Crucible advised me that that was an incorrect request on my part, that the Keeney & Ferm and the Steckel patents should be regarded by me as essentially one.

Q. That is the Steckel '214? A. It is the one that expired slightly after the Keeney & Ferm. I then amended my request to our people and asked that we arrive at a cancellation date with the expiration of the Steckel '214. The negotiations resulted in a cancellation 18 months hence, and we accepted that. We accepted that on the assurance of our people that by establishing a mill that came within the Keeney-Ferm and the Steckel we would get a type of product such as we sought at a cost which we would make a living out of and get our money back and have a commercial operation.

Q. Now, did you have in mind, Mr. Colvin, at the time that license agreement was entered into, that upon the

expiration of those two patents Crucible would at least explore the situation as to the patents that remained alive and determine whether or not it would be necessary to continue using the subject matter of any of those patents?

Mr. Webb: Objected to as leading, your Honor, grossly leading, and as immaterial and irrelevant.

* * *

[650] The Court: Well, I got an idea that may save a lot of time. Suppose I now, as a juror, tell you that I have been disabused that they had any sinister motive in selecting a certain date or in doing certain things to modify their mill. [651] Let's proceed on what actually happened.

* * *

Cross Examination by Mr. Webb:

[664] Q. This small reversing hot mill has admirably served the purposes of Crucible since it was put in, has it not, in so far as supplying to Crucible hot roll strip for its agricultural department and for its cold rolling department? A. It has supplied it as well as a compromise mill could, and we have not been disappointed in the mill, if that is what you mean.

[665] Q. Yes. A. You understand this hot roll product is not merchandisable in its as rolled condition, generally.

Q. The product of this hot mill is not merchandisable? A. Not for many applications requiring great accuracy or fine finish.

Q. But as a matter of fact the product of the McLouth mill was sold, was it not? A. Yes, sir.

Q. And the product of the second McLouth mill was sold, was it not? A. I couldn't answer you about the second because I had nothing to do with it, I was gone from

Detroit by that time. The first mill, we were large consumers of that, and I know that they had to install cold roll equipment in order to use a substantial part of the production which they could not sell.

Q. All you are saying is that there are many applications where the fine finish and excellent surface of the cold reduced product is required as distinguished from the type of surface that you get from a hot rolling operation? A. No, sir, I am not saying that. I am saying that the finer type of finish and more accuracy end to end, which comes off a continuous hot mill in hot form, is superior to the product which we get off our mill, and we knew that when we built the mill.

* * *

WILLIAM BRUCE LOCKWOOD (COLD METAL'S PRESIDENT) RECALLED

[688] *Direct Examination by Mr. Walker:*

Q. The reversing hot mills sponsored by your company have been generally known in the industry as Steckel reversing hot mills, have they not? A. Yes.

* * *

LEROY VALETTE (CRUCIBLE'S ROLLING MILL SUPERINTENDENT 1947-1951)

[698] *Direct Examination by Mr. Walker:*

Q. Mr. Valette, were you at one time employed by Crucible in connection with its reversing hot strip mill? A. Yes, sir.

Q. What position did you hold in that company? A. Well, I started as superintendent of what was originally

known as the Universal plate mill and later became division superintendent, which covered the hot rolling operations and the cold reducing and finishing operations.

[699] Q. Was that the same position that Mr. Barnes, who testified here earlier, held? A. Yes, that he has now.

Q. Mr. Barnes succeeded you as division superintendent? A. That's correct.

Q. In charge of the Crucible hot mill and cold mill? A. That's correct.

* * *

[700] Q. So that you were Division Superintendent of Crucible at the time the various changes were made in the hot strip mill that have been testified about here? A. That is right.

* * *

[722] Q. Are the pinch rolls of the Crucible mill actuated automatically, as one of plaintiff's witnesses said? A. Automatically?

Q. Yes. [723] A. As to their respective positions, pinch up or down?

Q. Yes, sir. A. No, sir.

Q. How are they operated? A. Manually.

Q. Is the deflector roll of the Crucible mill driven at the time the entering end of the strip passes that roll on its way into the coiler—— A. No, sir.

Q. —as Dr. Sachs said yesterday? A. On our modified installation?

Q. That's right. A. No, sir.

* * *

[731] Q. Now, as of January, 1932, Mr. Valette, was it usual or unusual to have a roughing mill in line with a

finishing mill with a roll table connecting the two? A. That was usual.

Q. Is the Cushwa patent an example of a roughing mill in line with a finishing mill? [732] A. It is.

Q. What is the operation of this mill shown in the Cushwa patent on this chart? A. Well, it shows heating furnaces for heating a slab, it shows a mill, marked 5, for the purpose of reducing that slab, and in the specifications they cite reducing it into the neighborhood of a half inch or less.

Q. In that particular mill stand, No. 5. A. Yes. And since it is a slab, it is reduced a—I mean, there are a number of passes taken in that mill to reduce it, since it couldn't be reduced in one pass from the slab. There is a holding furnace that Cushwa provides for the purpose of placing the reduced plate, in the event there is something that prevents it continuing on its normal course. There is a shear 17 for cutting off the ragged end of the breakdown. And then there is a series of six stands which provide six passes for the operation of reducing it from the breakdown to the desired gauge.

Q. Now, do you see any difference in principle between putting a roughing mill in line with a finishing mill, which is a reversing finishing mill, and this Cushwa arrangement of a roughing mill in line with a finishing mill, which happens to be a continuous finishing mill? [733] A. No, I don't. Both roughing mills serve to accomplish the same thing, and that is reduce the starting slab to a point that the balance can be finished in the finishing stand.

[734] Q. Is the finishing operation in the arrangement of the Cushwa mill conducted at the same heat, or without reheating in the sense in which you understand that term to be used in the Montgomery Patent '065? A. Yes.

Q. Is there anything unusual about having a cropping shear as a part of a mill comprising a roughing part and a finishing part? A. No.

Q. It was suggested yesterday by Mr. Wilson that the shear 17 of Cushwa could be used only to crop the leading end of the material as it entered the finishing mill and could not be used to crop the trailing end. What is the fact about that? A. Well, that would depend on the location of the shear, or whether the shear could cut well when the material is moving. I don't recall anything in the Cushwa patent that places that shear in a position to limit it to one end or the other.

Q. Would you look now at the middle panel relating to the Keeney patent, and tell me, what is the relationship between the mill arrangement shown on this panel and the finishing mill of the Crucible hot strip mill? A. When you say the relationship, I am not sure I understand you, Mr. Walker.

Q. I want to know, do you think the finishing part of [735] the Crucible hot strip mill is the same in principle as this apparatus shown by Keeney & Ferm, or whether you think it is different in principle? A. The principle of Keeney & Ferm and the Crucible operation are alike. The difference in Keeney & Ferm over Crucible is the manner in which they locate some of the appurtenances, the manner in which they lead the material into and from the coilers, the manner in which they divert the steel; but the process of reducing a breakdown to finished product discloses the same principle.

Q. Now, when you are making that answer with respect to the Crucible finishing mill, are you making any distinction for present purposes between the original installation and the modified installation? A. No.

Q. Both the original and modified installation, in your view, are the same in principle but different in detail from that in the Keeney patent? A. Detail is the only difference in the two.

* * *

[736] Q. Does this Keeney & Ferm patent have provision for rolling in the flat through this 4-high mill shown here? A. Yes.

Q. And when that is done how does the strip get through? Is something movable there? A. Yes. Let's see if I can find the right identification of parts. Adjacent each side of the 4-high mill and what Mr. Keeney termed the chutes are movable parts. As the drawing shows, one end of it is at the plane of the table and the other end is in a position to feed in the pinch roll. To roll without using the coilers, it was his suggestion that those be raised, the end closest the mill be raised so that they would lie clear of the table and not interfere with any rolling in the flat.

Q. Then when one reached a thinness such that he wished to coil it, what would he do? A. He would drop the chute to the plane of the table so that when the material emerged from the mill, instead of following the table 3 it would be diverted up the incline through the pinch rolls and then on into the coiler.

Q. Now, let's talk about the shears. Where are the cropping shears in this patent? A. The shears are noted as item 68, one on the mill side of each pinch roll stand.

[737] Q. Now, a point was made here the other day to the effect that those cropping shears wouldn't be much use because they couldn't be operated while the strip—the mill would have to be stopped in order to operate them, I think that was the point. What is the fact about that? A. Well, the Keeney-Ferm patent discloses that the material

would be on the reels with the trailing end between the pinch roll and the millstand itself.

Q. Yes? A. (Continuing) In the right-hand view the dotted line that shows that first chute, shows that in a position to drop a crop on the table. Now, if that were in reverse, in other words, if the material was in the mill and the crop shear was brought into effect, the front end would be in the pinch roll, or somewhere beyond that. So the material being wound on the reel, the trailing end between the pinch roll and the mill, the natural thing to do is to shear it and the resulting crop dropped to the table for disposal.

Q. Where is the roughing operation conducted in the Keeney & Ferm arrangement? A. Keeney & Ferm speaks of another stand. He doesn't show it in a drawing.

Q. Will you refer to that part of the text beginning in the paragraph at the lower right of this chart, "In operation, assuming that the table 3 at the right-hand side [738] of Fig. 1 leads from the roughing mill, the roughed-down strip will be carried on this table into and through the initial pass between the reducing rolls 1." Is it your understanding that the Keeney & Ferm means by that there is a roughing mill over to the right here somewhere from which a roughed down piece of material comes from right to left to the finishing mill? A. That is right.

Q. What, then, does Montgomery Patent '065 show over and above what Keeney & Ferm shows? A. I can find no distinction between the two. Montgomery '065 teaches or discloses a way of reducing the material in a roughing stand, advancing it to, that is, to a point where the finishing stand has only the finishing to do. In other words, he is dividing the work between two mills, half of it, or essentially half of it, being done in a roughing mill, the other half being done in the finishing mill.

Q. At what stage in the reduction does the occasion to crop the ends arise? A. The cropping of ends on a mill of this type is to forestall any problem when the material becomes very thin. An irregular end can elongate to two, three, four, five, six feet, in some cases, and since there is a limit as to how much you can feed into the coiler, it is advisable to crop the breakdown so that there is no way, or so that there is no [739] chance of having an exaggerated, distorted end to feed into the coiler. You are so close to being finished that at the time it is important that you insure that every pass will engage the coiler as it should.

Q. If a strip which has been roughed down by the mill to the right of the figure in the Keeney & Ferm patent comes into the finishing mill and up into the coiler on the lefthand side, would it be in condition to enter that coiler without having the front end cropped if the roughing operation was properly conducted? A. In the heavier gauges it is unlikely that there would be an ear, as we call it, or a fishtail, long enough in that thickness to prevent the coiler from picking it up properly.

Q. Would you consider that there would be likely to be any occasion to operate the shear on the trailing end, that is, the shear 68 at the left, on that first pass? A. No.

Q. What would be the operation as it continued from that point on? A. Keeney & Ferm, as I see it, provides a shear on each side of the mill so that either the head end or the trailing end, or both ends, can be sheared at any time during the finishing operation that the operator feels it should be done. In other words, he can elect to shear the trailing end on the first pass into the first coiler, but if it is not [740] necessary at that time he need not shear. By the same token, on the first pass into the opposite coiler, he has the option of shearing, or not shearing on the first pass.

He can delay it to any point where he thinks it might create some trouble.

Q. Or he can omit shearing altogether—— A. Or he can omit shearing altogether.

Q. —if the condition of the strip is such as to not require shearing? A. That is right.

Q. In your mill, Crucible mill, to what extent is this cropping indulged in? A. Well, we have one shear that is used for shearing our slabs, that is, the crop ends from the slabs when we make ingots, we have the shear for shearing the reduced ingot into a multiple number of slabs, and we use the shear to crop both ends of the breakdown that is going to be rolled in the 4-high reversing mill. We shear both ends for the simple reason that once we start the coiling operation it is too late to decide whether we should go back to that shear and shear it or not.

In the operation of flats, where ears or fishtails are of not too much importance, it is rare that we will shear the crop end at all.

Q. Where you have a thing that is going to be coiled [741] and you do crop, is it the purpose of cropping to help the material enter the bite of the rolling mill rolls, or to help it enter the coiler? A. The coiler.

Q. Did you consider that there was anything unusual as of January, 1932 to include a cropping shear in a mill having a finishing mill and a roughing mill, like Montgomery '065? A. No.

Mr. Walker: Yesterday, your Honor, I asked Mr. Lockwood if he agreed that the Keeney & Ferm patent had given the world a new tool and a new mode of operation; he said he didn't know. Then I tried to read that statement into the record from a brief. I didn't happen to have Mr. Webb's brief,

but I had that quotation from it in my brief. He got up and said I couldn't read it from my brief because he couldn't find it in his brief. Well, I had better luck.

In Mr. Webb's main brief for Cold Metal Products Company in the McLouth against Cold Metal, the presently pending case, page 142, he said this, one short paragraph—one sentence: "Surely a reference such as this '670 patent—" that is that original Steckel patent with the coilers but no pinch rolls—"whose teaching is inoperative and impractical, and which does not disclose many important elements and [742] features of the Keeney & Ferm patent, warrants litle or no consideration when used in an effort to invalidate a patent of the character of the Keeney & Ferm patent, which has given the world a new tool and a new mode of operation."

* * *

Q. Will you look at the fourth panel of this chart, D-7, which is directed to Steckel Patent '214, and tell me whether or not that reversing mill has provision for rolling both in the flat and in coilers in furnaces on each side of the mill? A. Yes, this discloses the fact that at the option of a mill builder that he can design this mill for the work to be done in one mill, or he can divide it between two mills, meaning roughing in one mill and finishing in the mill described by Steckel '214.

Q. You have in mind there the first paragraph of the text at the bottom which says, "I provide a mill which is relatively simple and compact in construction, employing preferably but a single reducing stand, although it may in certain instances be desirable to divide the work between

[743] two stands"? A. That is what I was referring to, yes.

Q. If that latter suggestion of having two stands were employed, what would be involved? A. Well, the situation would then become similar to that that Crucible has in its present installation, a stand somewhere in line ahead of the mill described in '214 that is capable of reducing a slab to a breakdown and then finishing that operation in a mill described by '214.

> Mr. Walker: I think it is pertinent at this point, your Honor, to give your Honor the praise that was heaped on this Steckel patent by its owner in the McLouth case, where this patent was charged to be infringed by the mill, instead of being an expired patent in the prior art. That is on page 30 of Cold Metal's brief in that case, and under the heading Steckel Patent '214 it says: "This patent, Exhibit PX-2, issued on an application filed May 4, 1931. It discloses the original mill built and operated at Youngstown's Briar Hill plant. It was the mill of this patent on which Cold Metal," and now it is italicized, "for the first time in the history of the world," italics ended "demonstrated the commercial practicability of hot rolling strip on a reversing hot mill, with coiler furnaces on opposite sides of the roll stand."
>
> * * *

[744] Q. I am going back to the first panel, Montgomery '065, the very last part of the text that is reproduced there, where it says, "This means, however, that the finishing mill can operate at maximum efficiency at all times, being confined exclusively to high speed rolling with coil-

ing between passes and not periodically converted from a high speed strip mill"—it says metal, but obviously means mill—"to a slow speed slabbing mill in accordance with the disclosure of the Steckel patent." That being Steckel Patent '214 that we were just talking about.

Now, is the finishing stand of the present Crucible mill confined exclusively to rolling with coiling between passes? A. No.

Q. What other kind of rolling is conducted on that [745] finishing mill? A. The Crucible mill, from the moment that I can remember starting the mill, has always taken at least one flat pass in the finishing stand.

* * *

Q. I would like to have you now look at Exhibit D-8 for identification, which is a similar collection of panels.

Mr. Walker: This, your Honor, is intended to present the case as we see it on Montgomery Patent '122, Claim 10, which is a claim directed to the control of the side guides. The individual panels of this chart were prepared in the same manner that I described previously, taken photographically from the patents referred to, underlining the things that we think are significant. That is true of the two left-hand panels; the two right-hand panels are reproductions of defendant's drawings which were received in evidence this morning.

Here again the patent in suit is at the left, the accused device is at the right, and in between is mounted what [746] we consider an obstacle to the application of the patent in suit to the accused device, whether it be by way of invalidity or showing limitations.

Q. Would you explain the operation of the side guides in this Steckel Patent '214? What are the side guides in the first place? A. Well, the side guides are numbered 109.

Q. They are shown parallel to each other—— A. They are shown parallel to each other.

Q. —near the ends of the rolls of the roll table? A. I didn't hear your last remark, Mr. Walker.

Q. They are shown parallel to each other near the ends of the rolls of the roll table? A. That is right.

Q. How are they supported? A. Well, the guide of '214 shows a mechanism of two parallel guides with linking arms resting on the roll table, so that when the roll tables are operated in one direction the guide automatically takes either an in or out position; rotating the rolls in the opposite direction the guide takes a completely opposite position, whether it is in or out.

Q. What is it that causes the guides to move in? A. The movement of the roll table.

Q. Which moves the side guard itself longitudinally and then this toggle mounting is such that that longitudinal [747] movement brings it in toward the center of the pass line? A. Yes. He discloses when operating the tables to convey material toward the mill, the guides function to come in to the edge of the material and on reversal of the mill and tables—on the opposite side of the mill the guides are so linked to come out, so that they are away from the material. When reversing, each set of guides takes an opposite position, that is, close together or strip width, going in and out to their outmost limits on the delivery side.

Q. How does that action, that is to say, having the guides closer together on the entry side and further apart on the delivery side compare with the operation of the side guides in Montgomery Patent '122? A. Well, they are

similar in action in that the guides on '122 are brought together on the entry side when the mill and its tables are moved to operate, for example, to the right, the guides to the left then will be in a position at strip width. On the opposite side of the mill, instead of the whole guide moving out to give clearance to the issuing material, he discloses a method of opening the guides at the mill end of the guide so that they provide a space for the material to issue without obstruction.

Q. That is to say Montgomery on the delivery side opens only the mill end of the side guide to create what he calls a converging throat between the guides on the delivery [748] side? A. That is right.

Q. And these guides on the entry side are parallel, are they? A. That is right.

Q. Like the guides of Steckel '214? A. Right.

Q. And the guides on the entry side of both Steckel '214 and Montgomery '122 are closer together on the entry side? A. That is right.

Q. And further apart at the mill end, on the delivery side? A. That is right.

Q. Now, in the Montgomery patent what is it that the operator does to bring about the reversal of the positions of these side guides when the direction of rolling is to be changed? A. Montgomery discloses a method of tying into the main controller magnetically operated valves so that when the strip proceeds from left to right the pistons involved take the position to put the strip—the guides on the left side of the mill in a parallel relation and on the delivery side in a wide or converging position. At the same time the tables, the rolls and everything move with the movement of that controller.

[749] Q. What is it that the operator does to cause those guides to reverse their position when the direction of

travel of the strip is to be changed? A. He moves the controller to a running position.

Q. And it is that movement that controls not only the motor but the positions of the guides? A. Yes, sir.

Q. How does the operation in Steckel '214 compare with that? What is it that the operator does in '214 to change the position of the guides when the direction of travel is to be changed? A. Since the guide in '214 is moved by the table rolls, he must also move the controller to start the mill and table rolls in motion.

Q. Well, you started with the result and ended up with the cause. If the operator of '214—he has a motor control there, doesn't he? A. Right.

Q. And he has to move it one way to make the mill go that way and move it another way to make the mill go the other way? A. That is right.

Q. Having done that, moved that controller to dictate the operation of the mill motor in a particular direction, does he have to do anything else in '214 in order to cause the [750] side guides to bring themselves to the proper position? A. No.

Q. That happens automatically? A. Automatically.

Q. Now, in the case of the side guides of the Crucible accused mill, are those parallel guides on both the exit and delivery sides as in Steckel '214? A. They are.

Q. Are they close together on the entry side and wider apart on the delivery side, as in Steckel '214? A. They are.

Q. What is it in the operation of the Crucible side guides that causes them to reverse their position? A. The stopping of the mill.

Q. Will you elaborate on that a little bit, please? A. Well, at Crucible, at the finish of a pass when the trailing end of the strip is at the mill, or just discharged, the controller is thrown to off, or on the other operator's desk there is a stop button that stops the mill and coilers, tables.

Q. A stop button that a man hits with his hand, you mean? A. Touches. At the moment that this controller or stop button is moved to stop everything, the Crucible guides then function to reverse themselves preparatory to the next direction [751] of operation.

Q. Does the mill ever stop by reason of a circuit breaker going out through overload? A. It can.

Q. What happens to the side guards if that happens? A. They change position just as though it were stopped by a controller or stop button.

Q. Well, now, have you had any experience with side guides that were controlled or caused to be actuated by the motor controller, as in Montgomery '122? A. Yes. When we first put the side guides on what we call automatic at Crucible, which was several months after the starting of the mill, we used exactly that feature. In other words, when the operator moved the controller to move the mill table rolls and coilers in a given direction, the guides would then automatically start to position themselves for the position necessary for that pass. For example, left to right, the guides on the left side would be positioned then to be close to strip edge, those on the right side, or delivery side, would be positioned to give the strip clearance, which was approximately five inches wider.

Q. Did you find that to be a desirable way to operate as compared with the way you operate the side guides now? A. No, we didn't find it desirable. In fact, we only operated that way for several months.

[752] Q. What was undesirable about it? A. We found that the material could be into the mill before the guides had taken position, and if the strip was off the center, the guides would then tend to curl the edges in their attempt to reach their final position. In other words, they were too late in assuming the position that was required.

Q. Does it ever happen in your mill, as presently constructed, that the mill has been stopped in a normal way with the trailing end just past the mill rolls and then for some reason the operator wants to make it travel a little further in the same direction? A. Yes.

Q. When the operator moves his control in that situation, in such a way as to make the strip move further in the direction it last moved in, what does he find to be the case with respect to the side guides? A. The side guides are in the wrong position at that time.

Q. What does he do about it? A. He can use what we call the manual guide resetting button, by touching that they will automatically reverse themselves from whatever position they are in, or he can work the mill controller, just turn it on and set it off again to reverse the position in the opposite direction.

Q. That is to say, give it a double jog? A. Give it a double jog.

[753] Mr. Walker: I don't recall whether I offered Exhibit D-8 for identification in evidence; if not, I now offer it.

The Clerk: D-8, formerly marked for identification, now marked for evidence.

(Received in evidence as D-8.)

Mr. Walker: I now tender Exhibit D-9 for identification. This is four panels, the left-hand one is again Montgomery '122.

This chart is directed, your Honor, at the subject matter of the high lift-low lift of the pinch rolls, the subject matter of Claims 6, 18 and 19 of this patent. Here again the same procedure has been followed, the left-hand chart, Montgomery '122, the

next chart, Steckel '214 being derived solely photographically from the patents, and the two right-hand pictures are reproductions of defendant's drawings received in evidence this morning. Here again the patent in suit is at the left and the accused device at the right, and the obstacle construing the patent to be infringed by the Crucible mill is in the middle.

I offer this in evidence as Exhibit D-9.

The Clerk: D-9, formerly marked for identification, now marked for evidence.

(Received in evidence as D-9.)

Q. Before I forget it, on what date was the magnetic [754] drive installed on the deflector roll of the Crucible mill? A. November 19——

Q. I am very sorry. This being the high lift-low lift, what I want is the date on which the hold-down roll was installed. A. That was October 29, 1951.

Q. When the pinch rolls of the present Crucible installation are in the pinch position, do they perform any functions that weren't performed by the pinch rolls in Steckel '214?

* * *

[755] A. No, they are both for the same purpose.

Q. When the pinch roll of the Crucible installation is in its up position does it perform any function that was not performed by the pinch roll of Steckel patent '214 when it was in its up position? A. No.

Q. What is your understanding as to the mode of operation of the pinch rolls of Steckel patent '214 as described in the text of the patent, with respect to coiling rolling? A. '214 discloses that the pinch rolls would be used for

feeding the material from the reel to the mill and, as I recall, also from the mill to the coiler.

Q. Did the pinch rolls of Steckel '214 have any function to perform with respect to tension on the strip? A. Yes, '214 did disclose that the pinch rolls could be used for exerting a forward tension on the material as it issued from the mill and a retarding tension on the entry side.

Q. Was there anything about the construction of the mill of this Steckel patent to prevent the operator [756] from withdrawing the pinch roll from the strip by raising it after it had performed its function of feeding the strip into either the mill or into the coiler? A. No.

Mr. Walker: At this point I offer in evidence as Exhibit D-21 stipulation between the parties dated March 21.

* * *

[757] Mr. Walker: And the final paragraph stipulates that during a certain period plaintiff has title to all the patents in suit.

And in that connection, I note that the assignment to Cold Metal of the Keeney & Ferm patent, about which there has been so much discussion, does not appear on the face of the patent or in the file wrapper.

May it be stipulated, Mr. Webb, that the application for that patent was assigned to Cold Metal by Keeney & Ferm individually on November 22, 1928, and then on November 24, 1928, there was executed a sort of confirmatory assignment by Crucible itself?

Mr. Webb: I will stipulate that the application was assigned to Cold Metal Process Company by Keeney & Ferm in November of 1928 and that in that same year an assignment was executed by Cru-

cible. I don't understand what you mean by a confirmatory document, but does that take care of it?

Mr. Walker: Yes.

The Clerk: D-21, stipulation dated March 21, 1956, in evidence.

* * *

[758] Q. Do you have a copy of the Mohler article—
A. I believe I do.

Q. —which is included in this stipulation, Mr. Valette?
A. Yes, I do.

Mr. Walker: That is Item 3 of the stipulation, Exhibit D-21.

Q. Is there any disclosure there of the withdrawal of the upper pinch roll from the strip during coiling rolling?
A. Yes.

Q. What is the part you have in mind? I think you will find it on page 11 of this article from the Iron and Steel Engineer of January, 1933. A. Well, the bottom paragraph on page 11, for example, "The pinch roll on the leaving side is then lowered" which indicates that it has been in the up position.

Q. How about the fourth paragraph from the bottom of that column, which reads, "It might be mentioned that the pinch rolls are raised on the leaving side because they are only required for entering the piece into the main rolls"? A. That's right.

Q. Assuming that the operator of the mill, like that of this Steckel patent '214, raised the pinch rolls [759] after they had performed their function of feeding the strip into the mill, or into the coiler, as the case may be, a distance of three inches, then would you compare what the operation of that mill would be as compared with the

operation of the present Crucible installation? A. I would say they would be identical.

Q. Let's develop that in a little more detail. In passing from the mill rolls to the coiling reel the strip in the Crucible mill passes under the hold-down roll, and then under the deflector roll, on its way to the coiler? A. That is right.

Q. And in passing that same course, from the mill to the coiler, as Steckel '214 when operated as I described, it would again pass under the pinch roll in this case and the deflector roll on its way to the coiler? A. That is right.

Q. Are any of those rolls driven during the coiling operation? A. No.

Q. In either '214 or the Crucible? A. No.

Q. What functions are performed in the Crucible mill by the hold-down roll? A. The hold-down roll on the Crucible mill is provided [760] for one purpose, and that is to maintain the strip that is traveling from one coiler to the mill, or from the mill to the coiler, below the upper edges of the guide box so that at any time that the material would tend to move sideways toward the guide box you would have a long face to resist any tearing or such things that might occur.

I might give a little bit of a demonstration here. This will stand more resistance along this whole face of the bench, but by coming across the guide like this——

Q. At an angle. A. —it is very readily turned over. And that is the reason that we provide a hold down to firmly hold that into position, just above the mill table and below the tops of the guides.

Q. Now, you spoke of the guide box originally, now you are speaking of the tops of the guides. Would you explain in a little bit of detail what the form of those side guides is.

or what you mean by the guide box? A. Well, we call the guiding apparatus on each side of the mill the guides or the guide box, inasmuch as it has a boxing effect.

The Court: What figure are you look at?

Mr. Walker: Figure A-10?

The Witness: I was looking at three, but let's [761] look——

Q. Look at Figure A-10, if you will, of D-3.

It is a black binder that we put in this morning, your Honor. I think you have it.

The Court: D-1?

Mr. Walker: No, D-3.

The Court: Anything that shows what you are referring to.

A. The reason we sometimes term it a guide box, normally when you talk about guides only you are not talking about a lower or upper part. When we refer to a guide box normally it is because it has a lower, a side and an upper part, in other words, to form a box.

Now, this box does not extend, of course, the whole length of the guide. It starts the boxing in here and directs the material, should it be turned up, down to the bite of the roll. This is a straight guide. It has a lower flange, but it doesn't have the upper flange at this point. So to prevent the strip coming in at a high angle and cutting across the top of this, or interfering with this top part, is what we call the box. The purpose of it is to maintain that line as parallel, you might say, with the table itself.

The Court: The pass line.

The Witness: The pass line.

[762] Q. Not strictly parallel but nearly enough to parallel to not run into the top flange? A. That's right.

Q. Now, what is the function of the low lift position of the pinch roll in Montgomery patent '122? A. Well, Montgomery '122 provided the low lift position to relieve it from the pinch position.

Q. Is it your understanding from the drawings and text of Montgomery patent '122 that it is any part of the intention of that apparatus to have the pinch roll in contact with the strip when it is in the low lift position? A. According to Montgomery '122 he continually talks about lifting the pinch rolls off the strip, or from the strip, or some such thing as that.

Q. And if it is lifted off the strip then it doesn't perform any hold-down function, such as the hold-down roll of the Crucible mill performs, is that right? A. If it is lifted—of course, he doesn't specify a distance, so we don't know what he is talking about in distance. And his purpose seemed to be to provide a method to relieve the pinch, get the pinch roll away from the material.

Q. And if it is lifted off the material then it doesn't hold it down, does it? [763] A. No.

Q. Do you have any understanding of the purpose of providing that low lift position described here by Mr. Freed of relieving the mill from the strain of having the pinch roll drop from a fully elevated position down to the pinch position? A. It hasn't been a problem in our experience. We operate it that way now, from 12 inch to pinch position, every time we use it, which is at the beginning of each pass, or at the trailing end of each pass.

Q. So that if there is any advantage from that standpoint in having a low lift position you don't take advantage of it? A. That's right.

Q. Now, how about the cushioning effect that is provided for the pinch roll in its low lift position in Montgomery patent '122, do you have an understanding of what I mean by that? A. As I understand Montgomery '122, the two cylinders that raise the pinch roll from pinch position to high lift position have a feature whereby the air can be locked above the piston. In other words, to effect the low lift position in Montgomery, assuming the pinch roll is in pinch, then in operating the low lift cylinder the low lift cylinder overcomes the contained pressure within the [764] cylinders that do actually the raising of and that are connected with the pinch roll itself, which has room for some compression and, I am assuming, some floating, should there be a situation of it created.

Q. These are all air operated in the Montgomery '122? A. I can't recall from memory whether he is talking about both.

Q. At least the long stroke cylinders are air, aren't they, because those are the cylinders that act as cushions? A. That is right.

Q. Now, in the Crucible hold-down roll, that piston is actuated by hydraulic fluid rather than air? A. That is right.

Q. Is that design such as to give that hold-down roll any cushioning ability? A. No. In fact, the cushioning—as we all know, we originally operated the mill according to the high lift-low lift features of Montgomery. The cushioning we found undesirable, inasmuch as any change in—or any condition that would allow that roll to raise up and down didn't give us what we felt a stable operation, so in converting over to the so-called auxiliary or hold-down roll we purposely put hydraulic pressure and substatnially greater [765] pressure than that we used in the old setup with air, so that we would have a rigid holding roll. In fact,

it came down and actually pressed against stops on the housing.

Q. I now ask you to direct your attention to another chart, Exhibit D-10 for identification.

(Marked Exhibit D-10 for identification.)

Mr. Walker: This one is directed to Montgomery patent '107, with particular reference to Claim 6 of that patent, on the subject matter of tensioning the strip, your Honor.

This chart has five panels. The lefthand one relates to Montgomery '107, the next one to the right to Steckel '670, and the next one to the right to Keeney & Ferm, the next one to the right to Steckel '214, and, finally, on the fifth righthand panel, the Crucible accused mill.

Here again the patent in suit is separated from the accused structure by those patents which we consider interpose obstacles to the application of the patent to the mill. All of them are derived photographically from the patent stated.

I offer it in evidence.

The Court: It may be marked.

The Clerk: D-10, formerly marked for [766] identification, now marked in evidence.

(Received in evidence as D-10.)

Q. Now it becomes appropriate to ask you for the date on which the magnetic drive was installed on the deflector roll of the Crucible mill. A. I remember it as November 19. I will just verify it. That was November 19, 1951.

Q. What is the situation with respect to tension in the strip in the mill shown in Steckel patent '670? A. Steckel

'670 discloses that each motor—each coiler motor is driven and may be operated at such a rate to maintain the delivered strip under tension.

Q. Would the tension, if the mill were so operated, be uniform or non-uniform between the coiling reel and the mill? A. I would say it would be uniform since there is nothing between the mill and the coiler to interfere with the uniformity.

Q. If the uncoiling reel were so driven as to impose tension on the strip, is there anything there to interfere with uniformity of tension all the way from the uncoiler reel to the mill? A. No, there wouldn't be.

Q. What is the situation with respect to tension on the strip between the coiler reels of Keeney & Ferm and [767] the mill of Keeney & Ferm? A. Keeney & Ferm operates a little differently in that between the coiling reel and the mill, or the uncoiling reel and the mill, there is a set of pinch rolls and Ferm does not disclose a method by which the pinch rolls can be retracted. But he does disclose that once the material is in the mill, from the feeding side to the winding reel on the exit side, that he disconnects the drive from the pinch rolls and they act as idlers.

Q. Well, let's get first to the question of whether there is any tension or not in the strip. A. Yes, there is.

Q. What creates that tension? A. On the unwinding reel he suggests a drag brake, so that the unwinding reel will have a tendency to hold back between the reel and the mill.

Q. Now, what would create forward tension in this mill, tension on the delivery strip? A. The winding reel creates the tension between the mill and the reel, actuated by the operator. Ferm also provides, in the event the operator has not accurately adjusted his winding reel to the speed of the

mill, and creates a loop between the mill and the reel, a device which I guess you could call a looping arrangement, for taking up that slack and holding it under tension until [768] the operator actually brings the reel into the speed that he desires to have for the tension that he wants to wind.

Q. Is that thing you have just been describing what is referred to in the third paragraph of this panel of the chart reading, "Tension is maintained yieldingly upon the looped strip, as shown in Figure 1, by means of the fluid pressure cylinders, and the size of the loop aids the operator in adjusting the speed of the rotation of the reel in the coiler to the speed of the reducing rolls"? A. That's right.

Q. Are the pinch rolls of Keeney & Ferm used to feed the material into the coiler or the mill rolls, as the case may be? A. Yes, both.

Q. And after they have performed that function what happens to the drive in Keeney & Ferm pinch rolls? A. He discloses using magnetic clutches between the pinch rolls and the driving motor so that the pinch rolls would operate as idle rolls.

Q. And would the presence of those pinch rolls have any material effect, in your opinion, upon the uniformity of tension between the winding reel in the mill and between the mill and the unwinding reel? [769] A. As against Steckel—an arrangement such as Steckel '670, I would say yes. The winding reel is supplying the force, for example, for the tension, but between the winding reel and the mill there is a pair of idler driven rolls, which are being turned by the winding reel, or the movement of the strip, due to the winding reel.

Q. Let's examine Steckel patent '214, the fourth panel of this chart, and consider that mill with its pinch roll raised three inches, following the suggestion in the Mohler article that we spoke about a few minutes ago, and see what the

situation in that mill would be with respect to tension on the strip. Would there be any tension, in the first place?

The Witness: I would like to have the question repeated. It is quite long.

(Question read.)

A. Well, I would say yes, there would be tension, but it would be applying it different than the original Steckel '214 suggests, where he used the pinch rolls for exerting some of the tension.

Q. So if you raise the pinch rolls they could no longer exert that tension? A. That's right.

Q. Would the coiler reel impose tension, if it [770] was properly driven? A. The coiler reel would be the force to impose the tension.

Q. And what, if anything, would there be in that mill to interfere with uniformity of tension all the way between the coiler reel and the mill? A. It would be a situation similar to Steckel 214. There is a roll 99 in the furnace, which is an idler roll, or bottom side of the furnace, which the strip ends around, and the force of the reel is required to turn that roll. Then the roll 68——

Q. The Steckel pinch roll? A. That's the top pinch roll in Steckel '214. If it were in a position to engage the strip, then additional force would be required to turn that roll.

Q. How would that situation compare with the situation in the Crucible accused mill? A. Well, they would be, in my opinion, identical.

Q. In both cases the strip would be in contact with two rolls, both of which are undriven? A. Right.

Q. In its passage between the mill and the coiling reel? A. Right.

Q. Now, in what circumstances is your deflector [771] roll driven, and in what circumstances is it not driven, in the installation as operated since November 19, 1951? A. When the mill is not coiling material it is necessary to rotate the deflector roll and the coiler for the purpose of preventing warpage. And it is only at those times that there is a drive on that deflector roll.

Q. What does the operator do with respect to the drive, is it operator controlled or is it automatically controlled in some way? A. Well, bringing it into a driven roll, or removing it from a driven roll, the operator on his control—I would like to refer to a drawing here. I believe it is A-23—A-25.

The Court: The operator's panel.

The Witness: A-25 is the assistant operator's. So far as the function is concerned, they apply on either desk.

A. On that drawing is shown, in the first line of controllers—coiler No. 2 selector switch, which shows: jog, off, normal and idle. To begin coiling the operator throws the selector into the normal position. That disconnects the driving clutch that drives the furnace deflector roll. Jog position is the position which engages the clutch. So that at the beginning of an operation, when [772] they get ready to coil, this selector is put on the normal position, and it is left on that position throughout all the passes of coiling. So throughout all the passes and at all times during coiling the clutch to that roll is disconnected.

Q. So that when the entering end of a strip approaches the coiler furnace it finds that roll stationary? A. Not driven.

Q. And any rotation that the roll does from that time until coiling rolling is discontinued, and you go back to flat rolling, the power for turning it comes from the strip itself? A. That is right.

[773] Q. In the left-hand panel, Montgomery '107, we have included at the top of the third column Claim 4 of the patent, the last clause of which reads, "and driving said guide roll to prevent frictional drag on the breakdown." What is your understanding of the meaning of that phrase "prevent frictional drag on the breakdown" as applied to this Montgomery patent structure? A. Well, my understanding of that particular part is that it is his intention to drive that roll at the same speed that the material is moving, so that the material itself has no effect on the movement of the roll. In other words, to synchronize the two so that the strip is not forced in any way to make that roll revolve.

Q. And if one did drive that roll at a speed precisely synchronized with the speed of the strip, would it be true that that roll would then be eliminated as a cause of creating inequality of tension in strip one side of that roll against the other? A. In my opinion, yes.

Q. Is that in your opinion a factor of any commercial significance? A. I would say no.

Q. In any event, whether it is or not, you don't take advantage of that feature in your mill as operated since November 19—— [774] A. We do not.

Q. 1951? As a matter of fact, Mr. Valette, is it commercially feasible to synchronize a roll that closely, that its peripheral speed would be precisely that of the strip? A. I would say there are circuits or methods by which two rolls of that nature can be. I know that Crucible's electrical circuit does not provide for driving that particular roll at the precise same number of feet per minute as the strip. We

have conditions that will have some variation in that. For example, our mill roll diameters are 27¼ inches down to about 26 inches, and each time you change that while the motors are attempting to drive it the same, actually the peripheral speed of each of these rolls then becomes different.

Q. If there were no patent consideration involved, would you prefer to have your deflector roll in your Crucible mill driven by the strip or driven by a motor during the coiling operations? A. Actually, I don't see too much difference; one is that you don't have to maintain equipment, that we have to maintain now.

Q. Well, you are speaking of the magnetic clutch, the intermittent drive? A. Yes.

Q. I am asking you about having any drive at all during [775] the coiling operations as compared with having the kind of a drive that Montgomery '107 is talking about? A. The drive isn't essential in so far as rolling strip is concerned. If it wasn't for the fact that you must prevent it from idling, we would never put a drive on in the first place, of any kind.

Q. Do I understand correctly, then, that as long as you had some way of driving it when you are not coiling, then you are indifferent as to whether it has its own drive during the coiling operations or is driven by the strip? A. That's it exactly.

* * *

[776] Q. Mr. Valette, I would like to have you state what functions the hold-down roll in Crucible's present installation performs? A. The only reason for putting that hold-down roll into the mill is to hold the strip at about the pass line, so that it is contained within the guides.

Q. Now, in the Crucible installation, before the installation of that hold-down roll, was that function performed by the pinch roll in its low lift position? A. Yes, it was.

Q. Was that function performed by the pinch roll of the Montgomery patent in its low lift position? A. I would say yes. I mean, depending on where he calls low lift in his patent. He doesn't state what his elevation is.

Q. Well, if you honor the statement of the text that that pinch roll is lifted off the strip, then does that pinch roll in low lift position perform the function of holding down the strip? A. In that case, no.

Q. Now, Dr. Sachs attributed to the pinch rolls of the [777] Crucible mill in the low lift position a couple of additional functions. One of them was to prevent the sidewise movement of the strip. Do you agree with him that the pinch roll of the Crucible mill in the low lift position performed that function? A. No, I don't.

[778] Q. Is that function performed by the hold-down roll in the present installation? A. No, I don't.

The Court: You mean, no it is not?

The Witness: What I mean to say is that the hold-down roll does not have any tendency to guide the material laterally, whether it is the pinch roll or the hold-down roll.

Q. Another function that Dr. Sachs attributed to the Crucible mill in its low lift position was something to do with the prevention of looping. What can you say about that? A. The hold-down roll cannot——

Q. No, I asked if the pinch roll in its low lift position—— A. The pinch roll cannot prevent looping in the low lift position for the simple reason that looping isn't a function of the pinch roll in the low lift position.

The Court: Wait, wait, let's have that answer again.

(Answer read by the reporter.)

The Court: No, I don't think he means that.

Mr. Walker: I don't even understand it.

The Court: No, I don't, either..

The Witness: Well, when you say does it prevent looping—as I understand the question, you said does it prevent looping.

[779] Q. Yes. What is your statement about it? A. Well, essentially what I said before.

The Court: Is that the function?

Q. Let me try it again. A. What I am trying to say is that the pinch roll in the low lift position is in a position so whether there is looping or whether is not looping it is going to be there. In other words, if the reel is not taking up the slack the pinch roll cannot change the fact that the loop is there.

Q. Now, do the pinch rolls of Steckel '214 have any effect in preventing looping? A. Well, the pinch rolls in '214, as disclosed, where they are driven, the situation is somewhat the same thing. If they are driven at the proper speed there is no looping; since they are in pinch position and there is looping, it means that the pinch roll isn't going fast enough to create the loop, so it is held between the pinch roll and the mill.

Q. If the pinch rolls in Steckel '214 were driven as the patent teaches, namely, in such a way as to impose tension on the strip, then would looping occur? A. Read that question again, please.

(Question read by the reporter.)

A. I still don't digest the question, will you try it again, please?

Q. Well, let's consider the delivery side of the Steckel [780] '214 mill. It is true, isn't it, that the Steckel patent teaches that the pinch roll on the delivery side shall be driven in such a way as to impose tension on the strip between the pinch roll and the mill? A. That is correct.

Q. And the strip will be held taut between the pinch roll and the mill? A. That is right.

Q. In those circumstances can it loop in that position? A. Not as long as it is driven to exert a forward tension it can't——

Q. All right. A. —form a loop.

Q. Now, on the entry side is it your understanding that the pinch roll on the entry side of the Steckel Patent '214 is also driven in such a way as to impose back tension on the strip? A. That is right, that is my understanding of the patent.

[781] Q. And if so driven, can the strip loop between the pinch roll and the mill? A. No.

Q. Now, let's consider that part of the strip between the pinch roll and the coiling reel. At what speed should the coiling reel be driven? A. It should be driven at the same speed or—let's start all over again. If you are winding the material on the reel, it should be driven at the exact same speed, or with a tendency to drive slightly faster.

Q. For what purpose? A. For the purpose of exerting tension.

Q. If tension is exerted that way, is the strip going to loop? A. It cannot loop.

Q. Now, the unwinding reel, at what speed is that supposed to be driven? A. The unwinding reel, the purpose of that is to do just the reverse. The intent is to drive the unwinding reel at a rate slightly less than the mill is receiving it, to exert a back tension or drag on it.

Q. And if the uncoiling reel is so driven, can looping occur between that unwinding reel and the pinch roll? A. No, it can't.

[782] Q. Do you consider it feasible to operate one of these reversing hot coiling mills without having tension on the strip, on both the delivered strip and the entering strip? A. I can't visualize it being operated at all, from our own experience.

Q. What has your experience ~~been in~~ that regard? A. That any time that there is a failure of tension on one reel or the other, as has been said by other witnesses, the material will flop from one side to the other; in other words, it will skid and do such things as that.

Q. Get into a sort of a mess? A. That's right. In other words, the steel is coming to the winding reel faster than it can take it, so it has no set place to go to. On the unwinding reel, the same thing will apply. If it is unwinding faster than the mill is receiving it, it takes the shape somewhat of a clock spring that has been let loose.

Q. Now is there any one of these patents that we've had under discussion here this morning that does make any provision for handling a loop in the strip if a loop should form? A. Keeney & Ferm has a device, in the event, starting a strip, the winding reel has not been synchronized to take [783] the strip as fast as it is coming from the mill, a device that will create a loop; in other words, to take up the excess number of feet between the mill and the reel.

Q. And that is the apparatus referred to—— A. That is the apparatus on our—I don't know what these exhibit numbers are.

Q. I can find it. It is on the middle panel of Exhibit D-10, the third paragraph, where it speaks of, "Tension is

maintained yieldingly upon the looped strip, as shown on Figure 1," where there is sort of a rack—— A. That's right.

Q. —that accommodates the loop, maintaining the tension. A. The devices he suggests on that same sheet are shown as Figures 5 and 6.

Q. Now, at record page 570 Dr. Sachs testified about still another function of the low lift position of the pinch rolls in the Crucible original mill where he said, at the middle of the page, "Now, the low lift position also has a certain function in tensioning the strip." Did the pinch roll position of the original Crucible mill have any such function as that? A. None to my knowledge.

Q. Does the low lift position of the Montgomery patent have that function? [784] A. None to my knowledge.

Q. Then the last one I can find, in the way of a claimed function for the low lift position of the pinch roll, is also at page 570 [App. 55a] of Dr. Sachs' position, where he says, "It keeps the strip away from the table rolls and the table aprons and thus eliminates some scratching of the strip. And since, of course, this is expensive material, like stainless steel, any damage to the surface of the material is a disadvantage."

Did the pinch roll of the Crucible mill in its low lift position have any function of keeping the strip away from the table roll? A. There is none—no such function. The tension applied for winding and unwinding is the function that keeps the material off of the table.

Q. And so long as the pinch roll is elevated off the strip, then it is immaterial, from the standpoint of getting the strip off the table, whether it be retracted to low lift or high lift, is that right? A. It doesn't make any difference. The higher it goes, the higher the strip will go off the table.

* * *

[791] *Cross Examination by Mr. Webb*:

Q. So that from a practical standpoint you found it desirable to go through the material in the flat on the first pass and then go into the coiler on the north side on the second pass? A. That's right.

Q. But you have operated the Crucible mill in such way as to go into the coiler on the first pass, have you not? A. I have never seen it successfully done, myself, Mr. Webb.

Q. It was operated that way at times while you were still there in charge of the operation of the mill, wasn't it? A. On the first pass I can't recall a time that we did it. As I said, when we first started the mill, knowing that this was the intent, we tried it and we didn't find any success or advantage in trying to coil on that first pass, and we dropped it as a procedure.

* * *

[803] Q. What do you mean by free scaling? A. Well, when you are talking about free scaling in the millman's terminology, you are talking about the formation of scale arising on the metal being reduced and then having a tendency to loosen up so that it can be removed.

Now, at Crucible we remove the free scale that arises from the time it leaves the 2-high roughing mill, just prior to entering the 4-high finishing mill.

Q. But when the material goes down the table to the finishing mill it is at a point where free scaling has substantially ceased, and, as I understand it, as you go into the finishing mill you take off that scale? A. The scale is forming at that time, Mr. Webb, as it progresses from one end to the other. And you understand, [804] we are cleaning scale all through the roughing operation by the same method, high pressure water.

Q. Yes. And, however, by the time you go down to the finishing mill the free scaling has stopped, has it not? A. I would say no.

* * *

[808] Q. Yes. Then the patent goes on and says, "The material enters the mill 15 while still hot and is coiled up in the coil-heating furnace after the first pass through the mill." Now, as I understand your testimony, Crucible has found it preferable from its operating standpoint to go through the mill without coiling on that first pass, and then to coil on the second pass? A. That is right, after the second pass.

[809] Q. Yes, as the material goes through the second pass the material is coiled on the north side, is that correct? A. That is right.

* * *

[917] *Redirect Examination by Mr. Walker*:

Q. Mr. Valette, I have already mentioned this cushioning business. What is the fact as to the nature of the hold-down given to the hold-down roll of the Crucible present installation by it fluid pressed piston? Is it a cushioning or isn't it? A. As I have said, the purpose for putting hydraulic fluid on that was to give us a firm position. When we had the air cushion the cylinder would move anywhere from a half inch to as much as a full top stroke of the cylinder. In other words, it could go ten—it could float eight or ten inches, which was an undesirable feature. We put hydraulic on so we could maintain a fixed point. Now, I did on cross-examination say there was some float, but it is in the [918] area, I would say, of at the most, ten per cent of what it formerly was.

EXHIBIT D-1, Fig. 1

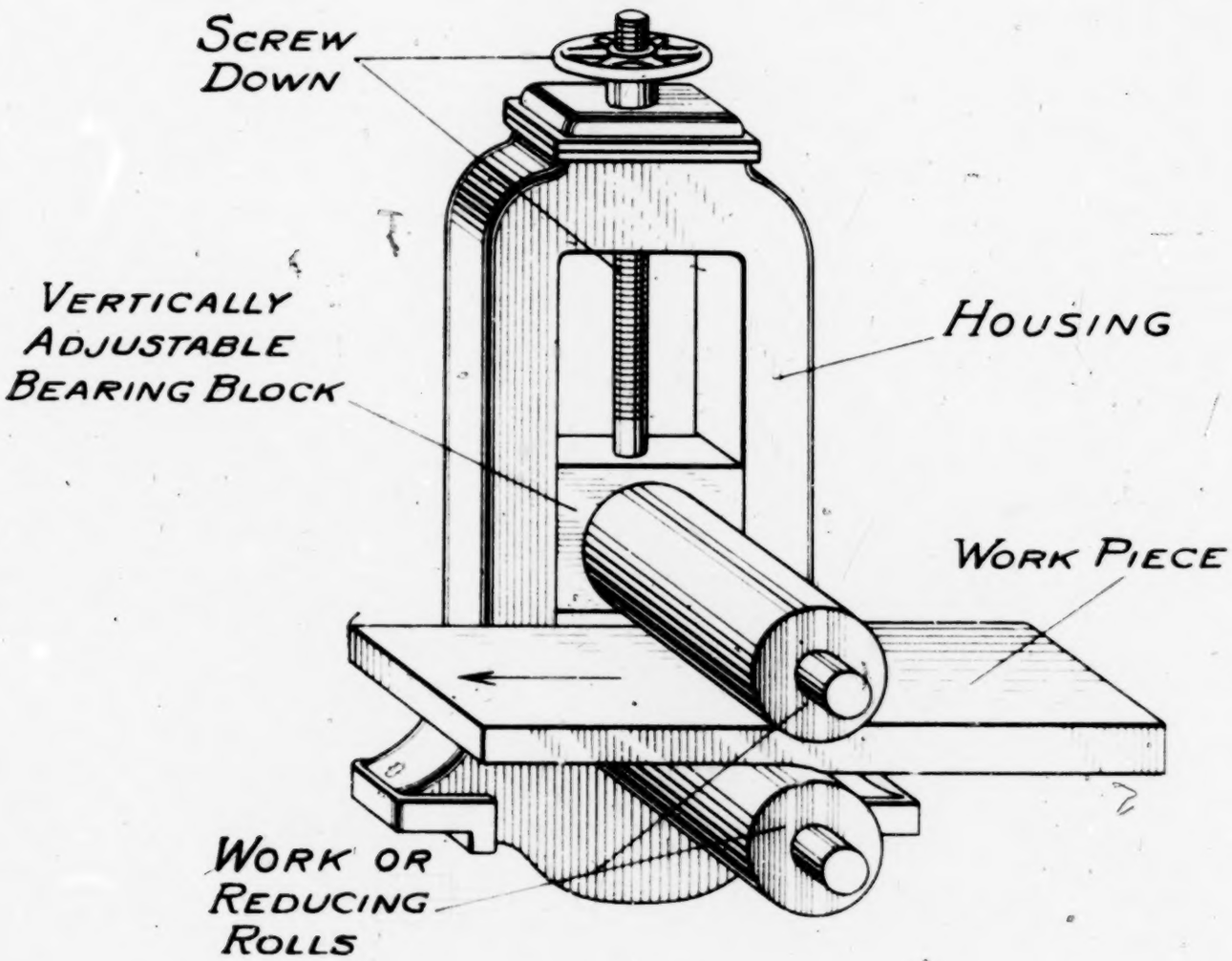


FIG. 1.
2-HIGH MILL

EXHIBIT D-1, Fig. 2

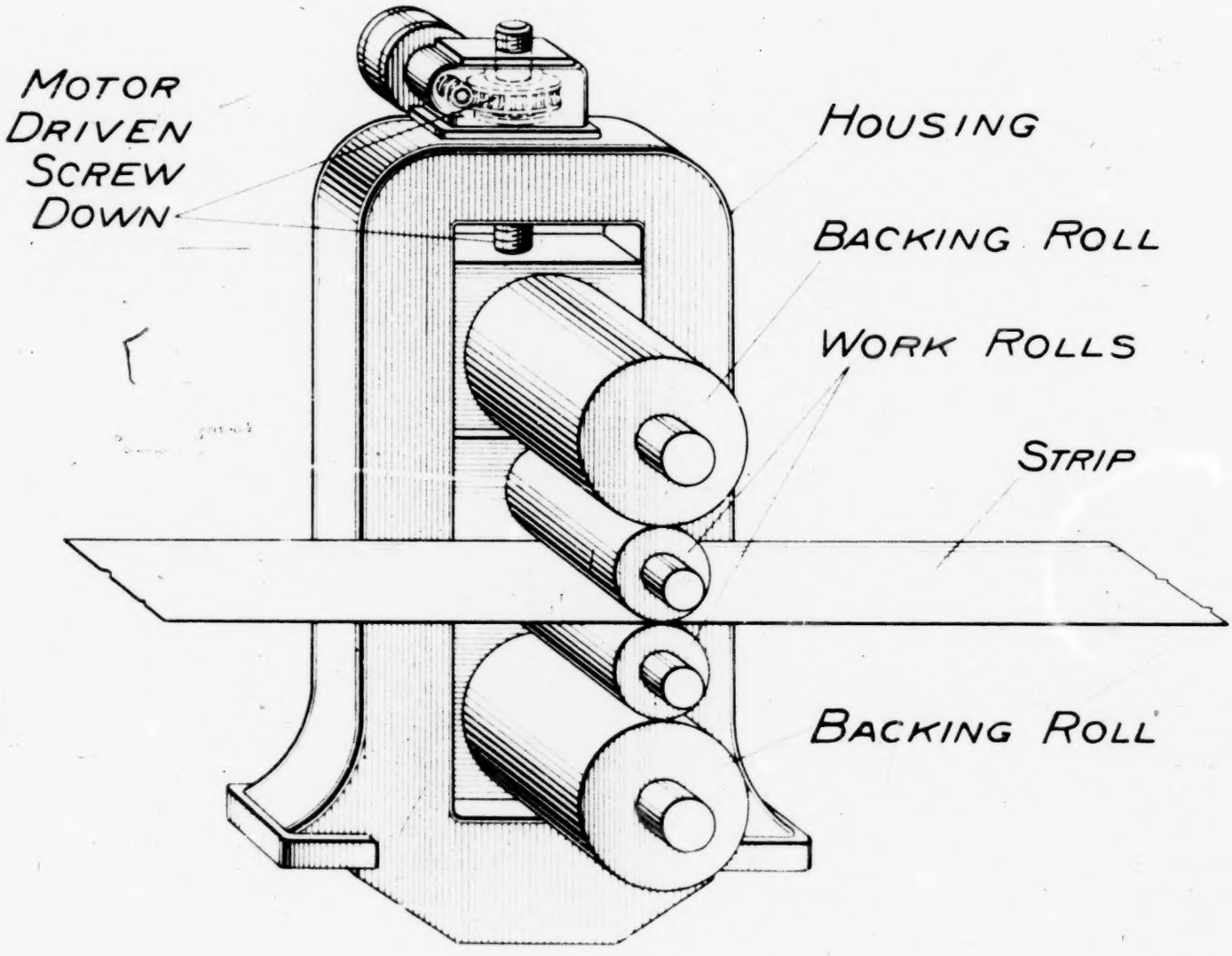
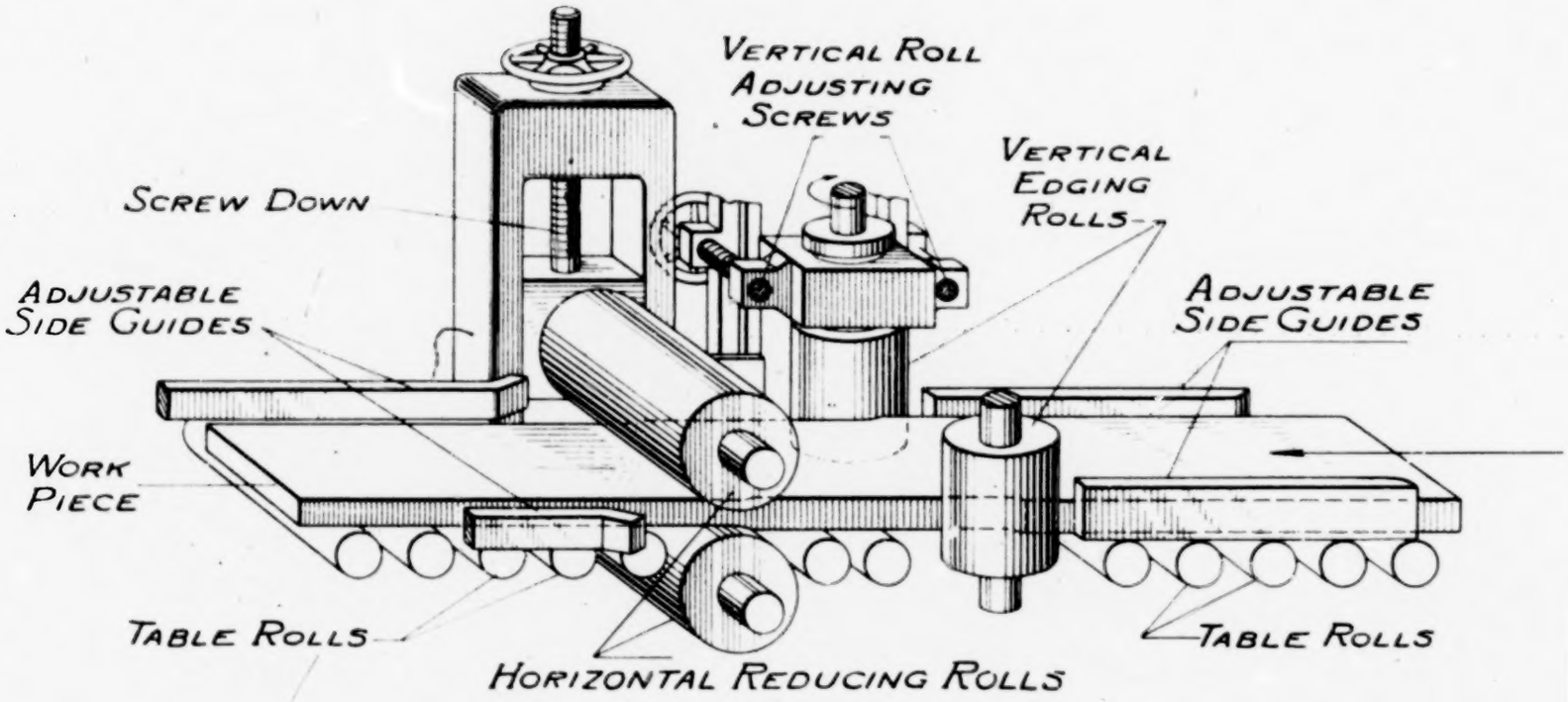


FIG. 2.
4-HIGH MILL

EXHIBIT D-1, Fig. 3



UNIVERSAL OR ROUGHING MILL

FIG. 3.
UNIVERSAL OR ROUGHING MILL

Q. You mentioned two or three-thousandths, I think, on your cross-examination—two or three-thousandths of an inch of variation of position; is that what you meant? Did you say two or three-thousandths? A. I don't recall exactly the figure that I talked about. The object was to hold it firm.

Q. As firmly as is mechanically possible? A. That is right.

Mr. Webb: Let's let the witness testify, please, Mr. Walker. There are reasons why I didn't stipulate on that printed description, as I have already said, and I don't think that it is necessary for you to testify on these points where there are contradictions. Let's get some testimony.

The Court: Well, the object is to hold it firm, then, is that right?

The Witness: That is exactly it, your Honor.

The Court: And generally speaking it is held firmly?

The Witness: Yes.

* * *

EXHIBIT D-1, Fig. 4

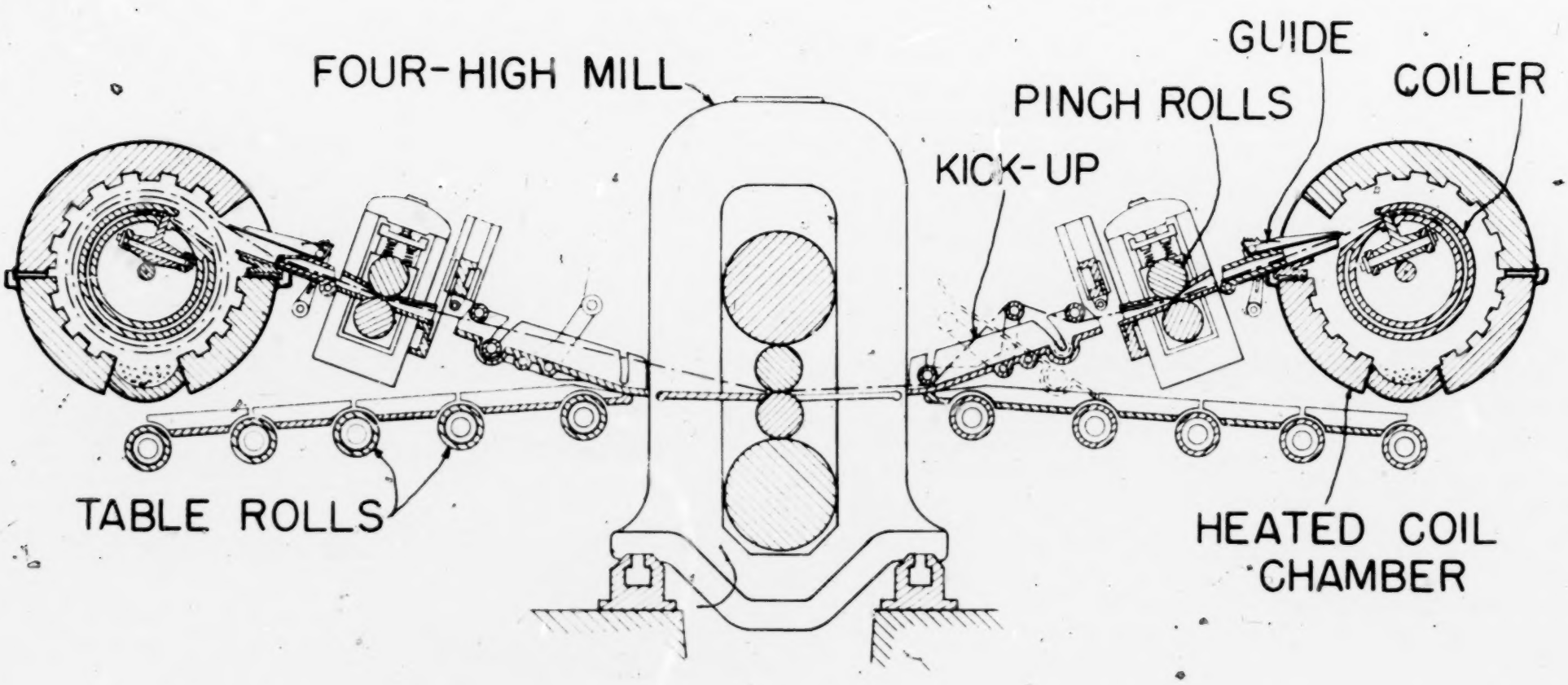


FIG. 4.

THE KEENEY & FERM MILL (ADAPTED FROM FIG 1 OF KEENEY & FERM PATENT NO. 1.918.968).

EXHIBIT D-1, Fig. 5

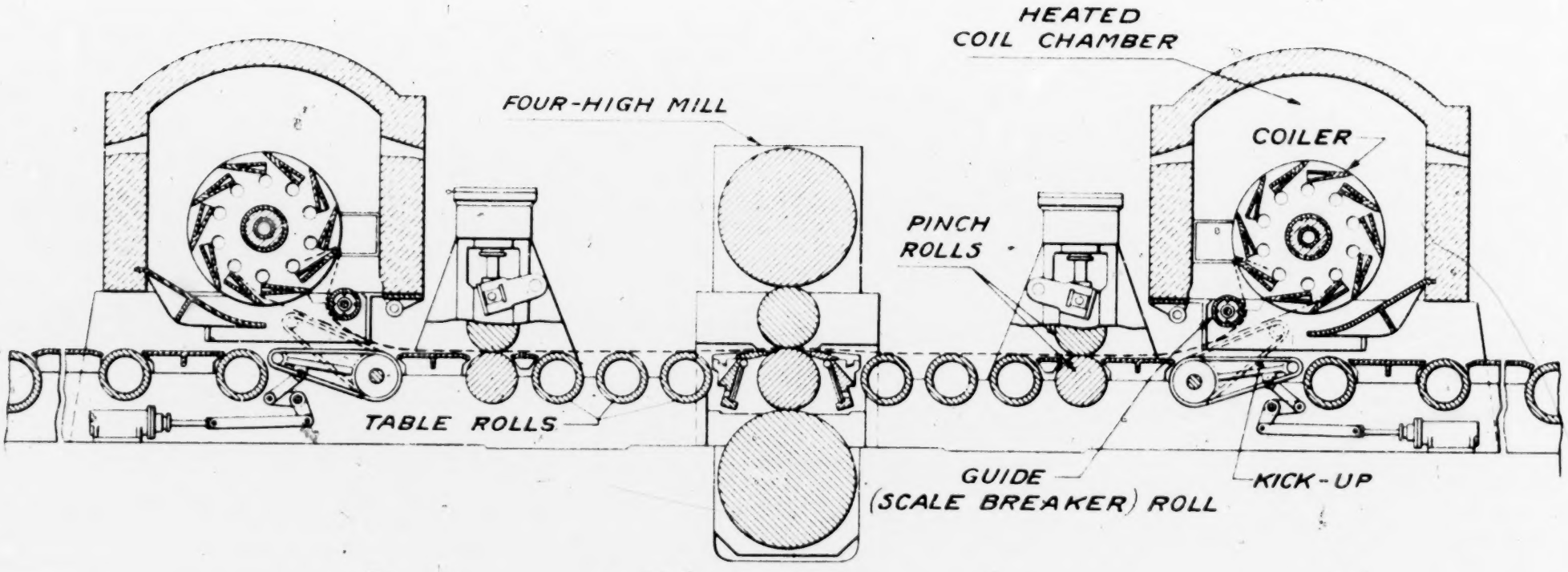
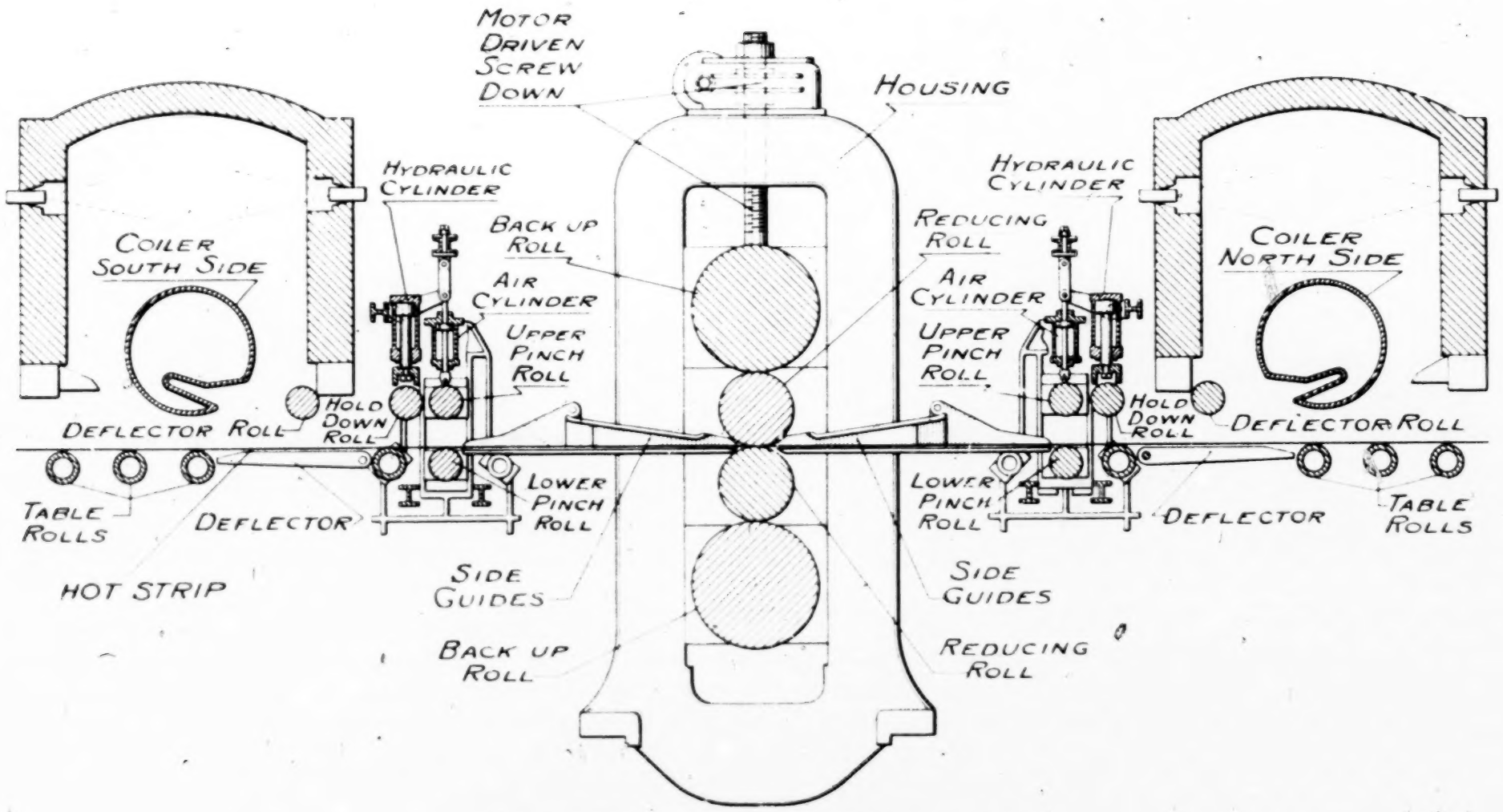


FIG. 5.

THE STECKEL '214 MILL (BASED ON FIG. 4 OF STECKEL PATENT NO. 1,977,214).

EXHIBIT D-1, Fig. 6



CRUCIBLE HOT STRIP MILL
4-HIGH REVERSING MILL STAND & COILERS

CRUCIBLE HOT STRIP MILL
4-HIGH REVERSING MILL STAND & COILERS

FIG. 6.

EXHIBIT D-1, Fig. 7

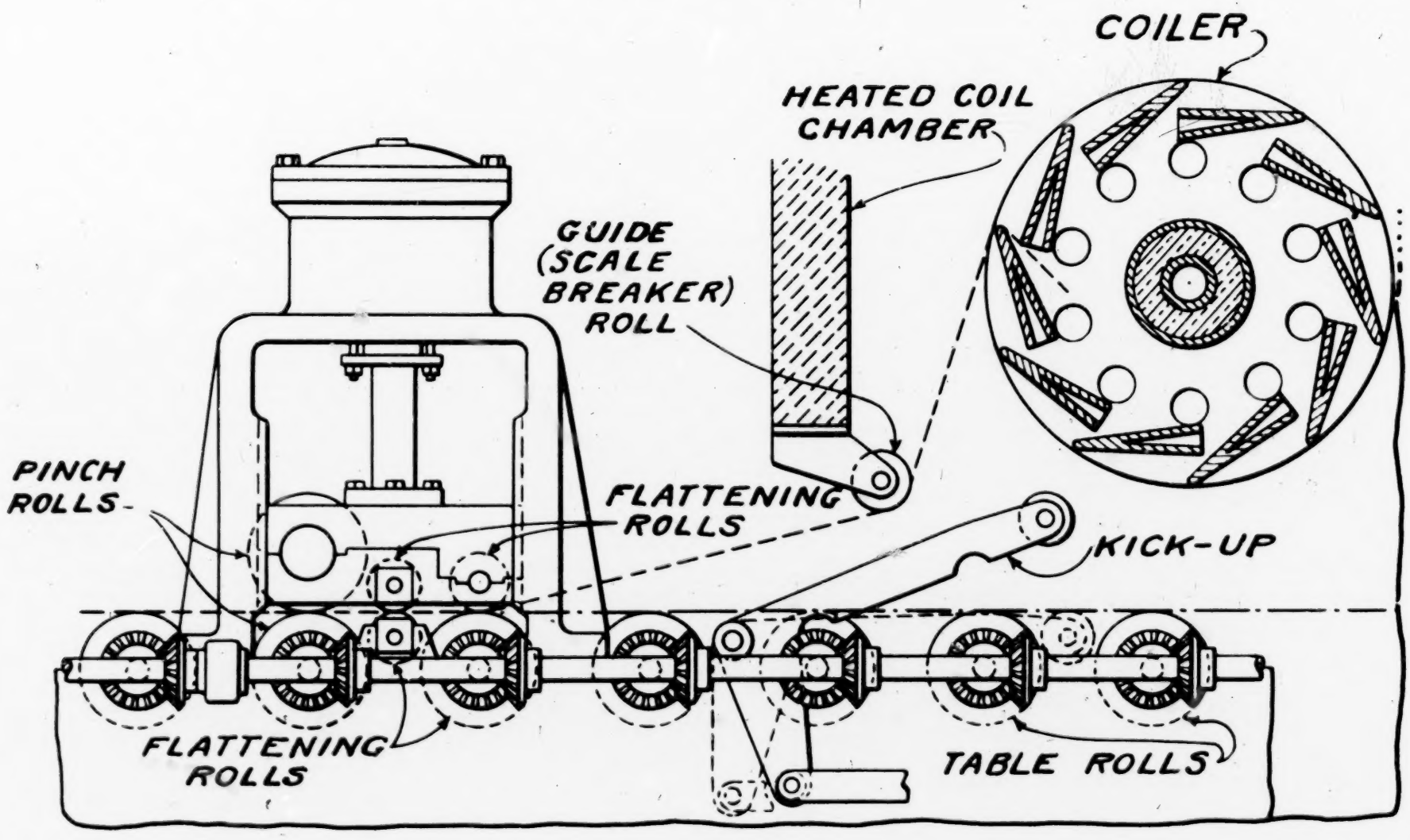


FIG. 7.

THE PINCH AND FLATTENING ROLLS AND THE COILER OF MONTGOMERY '122 (TAKEN FROM FIG. 4 OF MONTGOMERY PATENT NO 2,072,122)

EXHIBIT D-1, Fig. 8

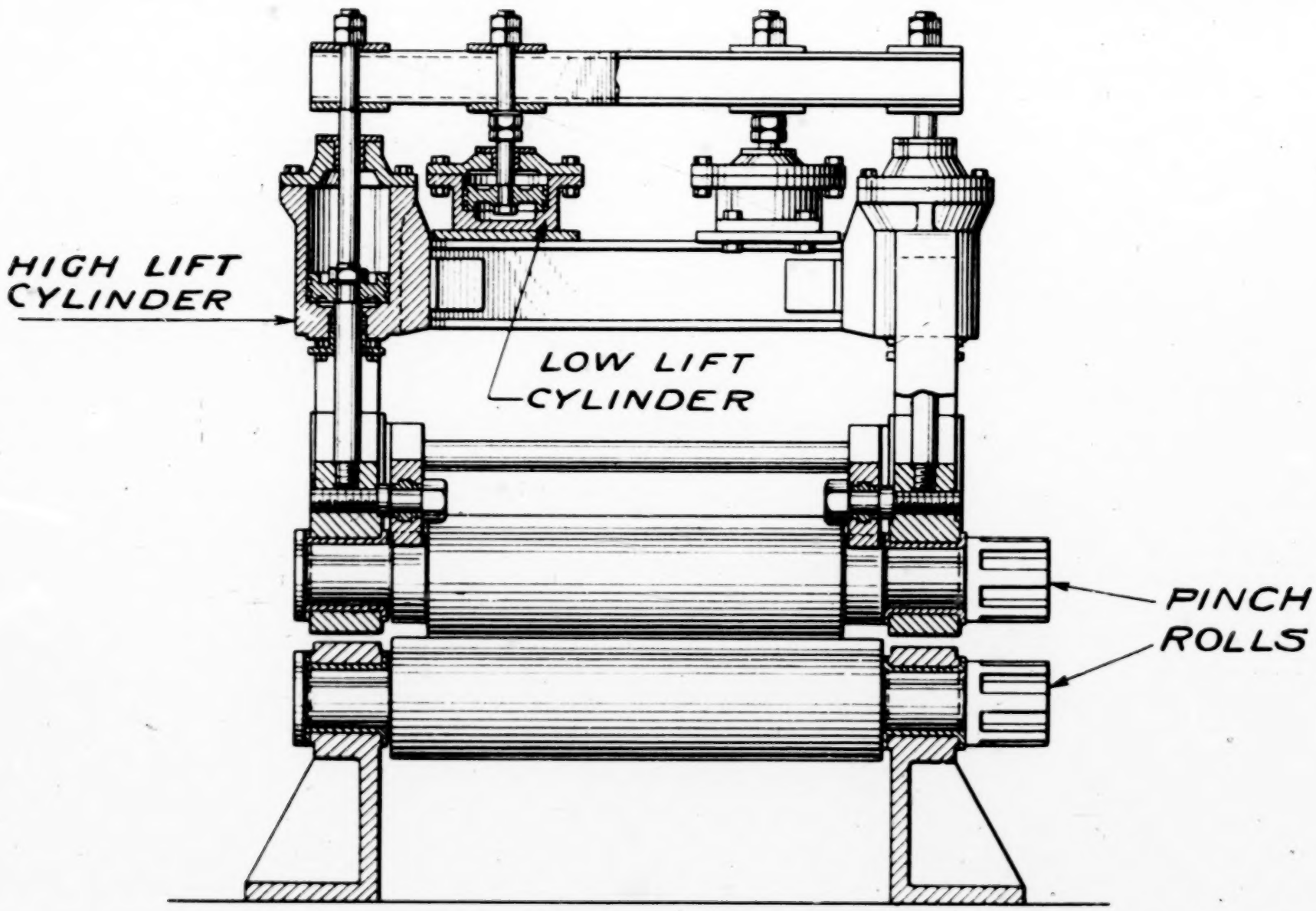
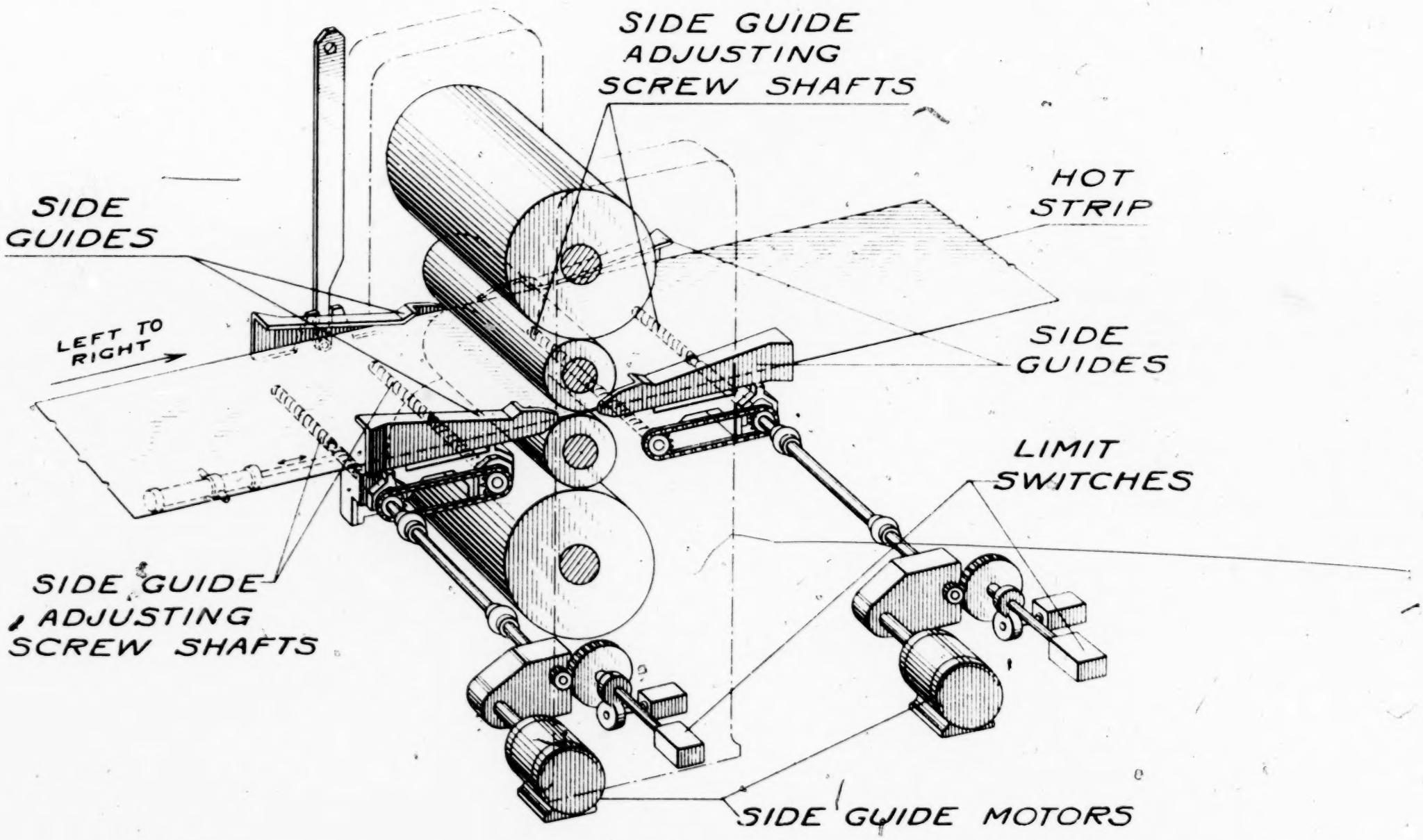


FIG. 8.

THE HIGH LIFT – LOW LIFT CYLINDERS OF MONTGOMERY '122 (TAKEN FROM FIG. 6 OF MONTGOMERY PATENT NO. 2,072,122)

EXHIBIT D-1, Fig. 9



CRUCIBLE HOT STRIP MILL

4-HIGH REVERSING MILL SIDE GUIDES

FIG. 9.

EXHIBIT D-3

UNITED STATES DISTRICT COURT

DISTRICT OF NEW JERSEY

No. 1231-52

THE COLD METAL PRODUCTS COMPANY,
Plaintiff,

v.

CRUCIBLE STEEL COMPANY OF AMERICA,
Defendant.

DESCRIPTION OF

APPARATUS AND OPERATION

OF THE

MIDLAND, PENNSYLVANIA HOT STRIP MILL

OF

CRUCIBLE STEEL COMPANY OF AMERICA

August, 1955

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DESCRIPTION OF

APPARATUS AND OPERATION

OF THE

MIDLAND, PENNSYLVANIA HOT STRIP MILL

OF

CRUCIBLE STEEL COMPANY OF AMERICA

The hot strip rolling mill of the Crucible Steel Company of America, located at Midland, Pennsylvania and used in the production of hot rolled strip consists of three mill stands. These are: a 32 inch by 72 inch scalebreaker mill; a roughing mill equipped with 31½ inch by 69 inch horizontal rolls and 28 inch by 34 inch vertical edging rolls; and a single stand 27 inch and 49 inch by 66 inch 4-high reversing mill equipped with coiler furnaces, coiling reels and auxiliary equipment. The hot strip mill was placed in operation as an integrated unit on an experimental basis in January of 1949. Several months of "tuning up" and changes in equipment as well as training of personnel were, however, required before commercial production was initiated on April 1, 1949.

The Crucible strip mill, as originally installed and operated, has been modified. These modifications were made primarily in the auxiliary equipment in immediate proximity to the 4-high reversing mill. In the description of the apparatus which follows, each of the modifications will be described. Similarly, the manner in which these modifications have affected the operation of the strip mill will be explained.

A. DRAWINGS

The drawings listed below correctly show the apparatus and operation of Crucible's hot strip mill at Midland, Pennsylvania, in its original and modified form, prior to the filing of the complaint herein.*

	Drawing No.
Diagrammatic Section of Complete Mill	1
4-High Reversing Mill Stand & Coilers—Plan View	2
4-High Reversing Mill Stand & Coilers—Modified Installation—Vertical Section	3

* Copies of these drawings will be found in the companion booklet, entitled "Drawings".

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Vertical Section at Pinch Roll & Coiler—Original Installation	4
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Deflector & Pinch Roll Assembly—Original Installation	6
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Pinch Roll Operation—Original Installation	8
Pinch Roll & Auxiliary Roll Operation—Modified Installation	9
Side Guide Assembly	10
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B. GENERAL DESCRIPTION

Throughout the description of the Crucible hot strip mill and the operation thereof, reference will be made to the drawings listed in paragraph A above.

Crucible's hot strip mill is used primarily to hot roll relatively thick ingots and slabs into relatively thin gauge stock in long lengths,

which may be finished flat and cut to length or wound into coils, depending on the final gauge and length. In the operation, a steel ingot is first heated in a batch type furnace to a uniform temperature throughout, transferred by crane to the hot strip mill and reduced on the scalebreaker mill and roughing mill to a relatively thick slab (Drawing A-1, upper section). After the ingot has been reduced to a slab both ends of the slab are sheared off and the slab is removed by a transfer mechanism from the hot strip mill line (Drawing A-1, right end of lower section). This slab is then conditioned in the grinding shop where imperfections in the surface of the slab are removed. After conditioning the slab is returned to the hot strip mill batch type furnaces and it is again heated to a uniform temperature throughout. The slab is then transferred by crane to the roll tables of the hot strip mill. The slab is further reduced in the scalebreaker and roughing mills to a relatively long breakdown of approximately an inch or so in thickness. The breakdown is carried on the roll table leading from the roughing mill to the shear (Drawing A-1, left end of upper section) where the ends may be cropped and then into and through an initial pass between the rolls of the 4-high reversing mill (Drawing A-1, lower section). The direction of rolling in the 4-high mill is reversed following each of several passes, and if desired the strip may be coiled on reels in heated furnaces on each side of the 4-high reversing mill. After the rolling has been completed the strip is carried by the roll table to a wind-up coiler where it may be coiled, or, in the alternative, may be cut to length on an up-cut shear (Drawing A-1, left end of lower section).

C. APPARATUS

The Crucible hot strip mill involves the use of a substantial amount of apparatus described hereinafter.

Heating Furnaces

Ten batch type, side door furnaces arranged in two banks are used to heat the ingots and slabs to be rolled on the Crucible hot strip mill (Drawing A-1, right end of upper section). These furnaces supply to the material the necessary heat to place it in a sufficiently plastic condition so that the hot rolling operations can be carried out on the hot strip mill. Each of the ten furnaces has a hearth area of 660 square feet and is gas-fired. Oil is available as a standby fuel. The furnaces are charged and emptied through side doors by means of one of two avail-

able cranes. Ingots charged in these furnaces range from a 9″ x 15″ ingot to a 20″ x 55″ ingot weighing from 1,100 to 24,000 pounds. Slabs charged range from 3″ to 9″ thick, 15″ to 50″ wide to 13 feet long, and weigh from 1,000 to 10,000 pounds. The ingot or slab is heated throughout to a uniform temperature of between 2200° to 2400° F. When removed from the furnace the ingot or slab is transferred by crane to the roll table of the hot strip mill. In the reduction of an ingot to hot rolled strip, the metal is heated in these batch type furnaces on two occasions—the first in the form of an ingot and prior to any rolling, and the second in the form of a conditioned slab.

Roll Tables

Roll tables are used to convey material being rolled on the hot strip mill from the time it is delivered by crane after being withdrawn from the heating furnace until it has been rolled to finished gauge on the 4-high reversing mill and is conveyed to either the up-coiler or to the transfer mechanism for removing material cut to length by the up-cut shear. The rolls of the roll table from the furnaces to the slab transfer pusher (Drawing A-1, right end of lower section) are reversibly driven by line shaft, i.e., there are several sections of table rolls, and the rolls in each section are driven by one motor. From the transfer pusher to the leveler (Drawing A-1, left end of lower section) the rolls are driven by individual reversible motors and are rotable in either direction. In addition to these driven rollers the roll tables also have aprons extending between some of the rolls. The lower pinch roll in each pair of pinch rolls, located on each side of the 4-high reversing mill, forms a part of the roll table and each such roll is driven. The deflector positioned beneath each coiler furnace, also forms part of the roll table (Drawing A-3).

Scalebreaker Mill

The scalebreaker mill is a 2-high mill positioned immediately south of the heating furnaces. (As originally installed this mill was a non-reversing mill. In January of 1955 the drive of the scalebreaker mill was modified and it is now a reversing mill.) The slab or ingot receives one pass on the scalebreaker mill. This pass removes the heavy furnace-formed scale from the slab or ingot and also causes a reduction in thickness varying between ½ to ¾ of an inch. The rolls of the scalebreaker mill are corrugated or fluted and are 32″ in diameter and 72″ in length. The mill rolls of this mill are directly connected to a 1500

horsepower constant speed motor which operates the mill rolls at a surface speed of approximately 207 feet per minute.

Roughing Mill

The roughing mill of the hot strip mill (Drawing A-1, left end of upper section) consists of a 2-high reversing horizontal mill and a reversible vertical edging mill. The roughing mill is used to reduce ingots to slabs and to reduce the reheated slabs to breakdowns for further rolling in the 4-high reversing mill. Between 15 and 40 passes are required to reduce an ingot to a slab, the number of passes depending upon the type of metal and the desired slab thickness which may be between 3″ and 9″. When rolling in this mill from a slab to a breakdown, which may vary in thickness from ¾″ to 1½″, 9 to 15 passes are required.

The two rolls of the vertical edger are adjustable in and out, toward or away from each other, and each roll has a diameter of 28″ and a length or height of 34″. The rolls of the vertical edger are driven by a 1500 horsepower motor with a variable roll speed of between 200 to 900 feet per minute. The two horizontally mounted, reversibly driven rolls of the roughing mill are 31½″ in diameter and 69″ in length. They are driven by a 5,000 horsepower motor with a variable roll speed of between 200 to 900 feet per minute. The roll table extends on each side of the roughing mill. There are adjustable side guides extending longitudinally over the roll tables on each side of the roughing mill which align the strip for its passes through the mill. The side guides on the north side of the roughing mill are pivoted at their outer ends to fixed supports. The inner or mill ends of the guides on the north side of the roughing mill are also pivotally supported and are attached to the vertical roll housings. The inner ends of these guides move in or out depending on the movement of the vertical roll housings. These guides diverge outwardly from the mill housings to the outer pivoted supports. On the opposite or south side of the roughing mill the side guides are arranged with their opposing faces parallel to one another and are actuated independently of the mill roll housings by electrical control.

The roughing mill side guides maintain the positions described during passes in both directions in this mill, i.e., the guides on the north side always diverge away from the mill and the guides on the south side are always parallel.

After an ingot has been reduced to a slab by the roughing mill, both ends of the slab are sheared off by means of the slab shear (Drawing A-1, left end of upper section) and the slab is removed from the hot mill pass line by means of the slab transfer pusher (Drawing A-1, right end of lower section). The surface of the slab is then conditioned in the grinding shop. This surface-conditioned slab is then returned to the heating furnaces, reheated to a uniform temperature throughout of between 2200 to 2400°F. and transferred to the roll tables for further reduction to a breakdown. When the slab has been reduced to a breakdown in the roughing mill its temperature is between 1700 and 1900°F. The breakdown is passed on the roll table to the slab shear, and if the breakdown is to be reduced on the 4-high reversing mill to hot rolled strip with coiling between passes, both ends of the breakdown are sheared in the slab shear. If the material is not to be coiled between passes on the 4-high reversing mill the ends of the breakdown are not sheared at this time, but when the rolling has been completed in the 4-high mill the material is cut to sheet or plate lengths in the up-cut shear at the south end of the hot strip mill line (Drawing A-1, left end of lower section). In either case, after the slab has been reduced to a breakdown, the material, without reheating, passes on the roll table from the roughing mill to the 4-high reversing mill.

As the breakdown approaches the 4-high reversing mill unit it is sprayed both top and bottom by high pressure water sprays and steam jets for the purpose of removing scale from the breakdown. The water spray and steam jets are located a short distance from the north coiler furnace, between the slab transfer pusher and the coiler furnace (Drawing A-1, right end of lower section). The temperature of the breakdown at the time it reaches the 4-high reversing mill for the first pass is between 1600 to 1800°F., approximately 100° less than when the breakdown received its last pass on the roughing mill.

4-High Reversing Mill Unit

As originally installed and operated, this unit of the Crucible hot strip mill comprised a 4-high reversing mill stand; a roll table extending on each side of the mill stand; movable side guides on each side of the mill stand; pinch rolls on each side of the mill stand, each set consisting of a reversibly driven upper and lower roll; a coiler furnace on each side of the mill stand; a motor driven coiling reel in each coiler furnace; a deflector or billy roll adjacent the mouth of each coiler furnace, and a deflector forming a part of the roll table on each side of the mill stand

for deflecting the material into the coiling reels in the coiler furnaces (Drawings A-2 and A-4).

In the modified installation, adjacent each set of pinch rolls and between the pinch rolls and the coiler furnace is an auxiliary or hold-down roll (Drawings A-1, A-3, A-5, A-7 and A-9).

The principal component parts of this 4-high reversing mill unit, both for the modified and original installation will now be described.

Mill Stand

The 4-high reversing mill stand is shown in the drawings A-1 to A-3 and A-11 to A-22 inclusive.

The mill stand comprises a housing with four rolls mounted in the housing, one above the other. The two smaller inner rolls are the reducing or working rolls, between which the material passes as it is rolled. The two outer rolls are the backing rolls, each of which is approximately 49 inches in diameter and 66 inches long. The working rolls are approximately 27 inches in diameter and have a working face 66 inches long. These working rolls are driven by a 5,000 horsepower, 70-150 RPM direct drive electric motor through a pinion stand (Drawing A-2).

The working rolls may be moved to a position in contact with each other, or at the other extreme, to a position where they are separated a maximum of approximately 5 inches. The adjustment toward or away from each other is accomplished by means of electrically operated screw-downs controlled by the 4-high mill operator. Each screw-down is operated by a 250-volt D.C. motor. After each of the passes through the 4-high mill the rolls are brought closer together in order further to reduce the strip on the succeeding pass. The mill stand is equipped with water sprays to cool the mill rolls.

Side Guides

On each side of the 4-high reversing mill in immediate proximity to the working rolls is a set of side guides (Drawings A-1, A-2, A-3, A-10 and A-23). The two pairs of guides on opposite sides of the mill are identical.

The faces of each pair of guides are maintained parallel one to the other during rolling in either direction. The guides may be adjusted in or out, toward or away from each other, by means of threaded shafts geared to a motor having limit switches for stopping the guides at their

proper in and out positions (Drawing A-10). Each pair of guides is used as an entry or delivery guide, depending on the direction of travel of the strip. On the entry side the guides are adjusted substantially to strip width and on the delivery side, the guides are adjusted to strip width plus 5 inches (See Drawing A-23 for the two possible running positions of the guides). Each of the side guides contains several orifices for steam jets which are positioned slightly above and at an angle to the material being rolled (Drawing A-3). These steam jets are used to remove scale from the material between passes. Means for controlling the actuation of the guides will be discussed in detail hereafter.

In addition to these guides one set of adjustable side guides, installed in the Spring of 1949, is positioned immediately adjacent and to the north of the north coiler (Drawings A-1 to A-3). These guides, operated entirely independently of the parallel guides described above, are for the purpose of aligning the breakdown as it approaches the 4-high reversing mill unit.

Pinch Rolls

The pinch rolls on each side of the 4-high reversing mill stand and their operation, as originally installed, are illustrated in Drawings A-4, A-6, A-8, and A-11 to A-16. The pinch rolls and their operation, as modified, are illustrated in Drawings A-1, A-3, A-5, A-7, A-9 and A-17 to A-22. Each pair of pinch rolls is mounted in a pinch roll housing. The bottom roll is on a level with the pass line. The top roll is adjustable vertically and is mounted directly above the bottom roll. Each roll is reversibly driven by an electric motor.

As originally installed and operated, the top pinch roll of each pair of pinch rolls could be moved into one of three positions (Drawing A-8). These were: the pinch position (left-hand view), in which the strip was pinched between the two rolls; the low lift position (middle view), in which the top pinch roll was 1-½ inches above the bottom pinch roll; and the high lift position (right-hand view), in which the top pinch roll was 12 inches above the bottom roll. In the original installation each upper pinch roll was actuated into its pinch or into its high lift position by means of two identical piston actuating air cylinders mounted as an integral part of the pinch roll housing above the ends of each pair of pinch rolls. To achieve the intermediate low lift position, another air cylinder, housing a short stroke piston, and mounted midway between the ends and above each upper pinch roll, was utilized in conjunction with the two end air cylinders (Drawing A-8, middle view).

A plunger or piston operated within each air cylinder and to effect the pinch position, air under pressure (Drawing A-8, left-hand view), was introduced through the upper air line of each cylinder. To effect the high lift position the air was exhausted from above each piston and introduced under pressure through the bottom air line of each cylinder (Drawing A-8, right-hand view). To effect the low lift position the air above the piston in each of the end cylinders was airlocked (cushioned) and air under pressure was introduced through the bottom air line of the middle cylinder, causing the short stroke piston to go to its uppermost position and thus raising the upper pinch roll to a point 1-½ inches above the lower pinch roll.

In the modified installation (Drawings A-5, A-7, and A-9), and its operation (Drawings A-17 to A-22), the top pinch roll of each pair of pinch rolls may be moved into one of two positions (Drawing A-9). These are: the pinch position (left-hand view), in which the strip is pinched between the two rolls; and the up position (middle and right-hand views), in which the top pinch roll is 12 inches above the bottom pinch roll. In this modified installation each upper pinch roll is actuated to its up or to its pinch position by means of the two identical piston actuating air cylinders mounted above the ends of each pair of pinch rolls. The short stroke air cylinder previously used to actuate the upper pinch roll to its low lift position was removed by October 29, 1951.

Auxiliary or Hold-Down Roll

There was no auxiliary or hold-down roll in the original installation. In the modified installation an auxiliary or hold-down roll adjacent each pair of pinch rolls maintains the strip, when it is being coiled, below the top edges of the parallel side guides. Installation of these hold-down rolls was completed October 29, 1951. Each hold-down roll is a retractable idler roll which may occupy one of two positions (Drawing A-9). These are: the up position (left and right-hand views) in which the roll is 12 inches above the level of the pass line; and the down position (middle view) in which the roll is 3 inches above the level of the pass line. The hold-down roll is actuated to either of these positions by means of a piston actuating hydraulic cylinder independent of the air cylinders previously referred to which actuate the pinch roll. This hydraulic cylinder is positioned above and between the ends of the hold-down roll (Drawing A-7, View X-X). A plunger or piston operates within the hydraulic cylinder and to effect the up position, hydraulic fluid is introduced under pressure through the lower oil line of the

cylinder and the hydraulic fluid above the piston is exhausted through the upper oil line (Drawing A-9, left-hand view). To effect the down position hydraulic fluid under pressure is introduced through the upper oil line and exhausted from below the piston through the lower oil line (Drawing A-9, left side of middle view).

A compressed air supply is employed for raising and lowering each upper pinch roll so that it will yieldingly engage the strip being rolled. Hydraulic pressure is employed to actuate the hold-down, since it must be held rigidly in its lowered position during rolling.

The positioning of the pinch rolls and the auxiliary or hold-down roll is manually controlled by means of electric switches actuated by the operator in the manner to be described hereinafter.

Deflectors or Kick-Ups

Deflectors or kick-ups in the original and modified installations are positioned immediately in advance of and beneath the coiler furnaces (Drawing A-1, A-3 to A-7, and A-11 to A-22). Each deflector is a casting in the form of a platform consisting of a series of separated bars. The deflector may be moved from a horizontal or down-position to an elevated or up position in which it extends at an angle of approximately thirty degrees to the pass line of the material. When actuated to divert the strip into the coiler furnace the deflector is raised to its up position so that the end farthest from the 4-high mill stand is raised to a position immediately adjacent the coiling reel in the coiler furnace (Drawings A-4 and A-5).

When not employed to divert the strip into the adjacent coiler furnace the deflector is maintained in the horizontal or down position.

Each deflector is operated by means of a rocker arm connected at one end to the under-side of the deflector by means of a link and at its other end to a deflector-operating rod which in turn is connected to a deflector-operating cylinder. The deflector-operating cylinder is a hydraulic cylinder which in turn is actuated by electrical controls.

Coiler Furnaces and Coiling Reels

Above the deflectors and the roll tables are large gas-fired furnaces (oil may be used as a standby fuel) within each of which is a coiling reel for coiling the hot strip (Drawings A-1 to A-5 and A-11 to A-22).

Each furnace has an opening in the bottom through which the hot rolled strip passes as it is being wound or unwound from the coiling reel within the furnace.

The temperature in each coiler furnace is maintained between 1800°F. and 2000 F. These furnaces prevent undue heat loss in the material during the rolling.

The cylindrical coiling reel mounted in each of the furnaces has a diameter of 48″ and a face 66″ long. As originally installed each coiling reel was driven by a 150 horsepower reversible motor. In July, 1953 an additional 150 horsepower motor was added to each coiling reel driving system.

At the begianing of each pass on which the strip is to be coiled after passing through the 4-high mill, the coiling reel upon which the strip is to be wound is brought to a stop automatically with its mouth or slot positioned to receive the advancing strip (Drawings A-12 to A-14 and A-18 to A-20). The leading end of the strip goes into the slot of the coiling reel a distance of about three feet, at which time the reel is rotated in a direction having a component of movement opposite the direction of movement of the strip as it enters the reel. When rotated in this way the strip is bent over the lower lip of the coiling reel slot and thus gripped by and secured to the coiling reel, so that, as the reel continues to rotate, the strip is wound around the outer surface of the reel. When the strip is not being reeled, the coiling reels rotate slowly at idling speed to prevent warpage caused by the heat of the furnace (Drawings A-11, A-16, A-17 and A-22).

Deflector Rolls

A deflector roll (sometimes referred to as a guide or billy roll) is positioned above the deflector and beneath the inner bottom edge of the coiler furnace wall closest to the 4-high mill (Drawings A-1 to A-5 and A-11 to A-22). During winding and unwinding from the coilers the strip being rolled is bent around the deflector roll. As originally installed in January 1949 each deflector roll was an idler roll, i.e., it was not driven by motor at any time, but was turned only by frictional force resulting from contact with the strip during coiling and uncoiling from either reel. At all other times these rolls were stationary which resulted in warpage due to the furnace heat. Shortly after operations began on the original installation, i.e., within a few weeks thereafter, this arrangement was accordingly modified and a low horsepower motor was installed to drive each deflector roll. The roll was driven during reeling operations, and the direction and speed of the roll were conformed to the speed and direction of rotation of the mill rolls through interconnection with the main mill motor controller. At other times these rolls were motor-driven slowly at idling speed to prevent warping. On No-

vember 19, 1951 installation and testing of a further modification of each deflector roll was completed. As modified, each deflector roll is intermittently driven by motor—when strip is being wound or unwound from the coiling reel it is not motor driven but operates as an idler roll and hence turns only by the frictional force of the strip; when no strip is being coiled or uncoiled each deflector roll is motor driven to prevent warpage due to uneven heating by the coiler furnaces. A motor and interposed disengageable magnetic clutch drive is used for thus driving each of these deflector rolls. When motor driven the deflector rolls are interconnected with the table rolls. Starting, stopping, accelerating, or decelerating of the table rolls correspondingly starts, stops, accelerates or decelerates the deflector rolls. The electrical controls for actuating these deflector rolls will be described hereinafter.

Feed Rolls, Up-Coiler, Up-Cut Shear and Leveler

Beyond the coiler and coiler furnace on the south side of the 4-high reversing mill are positioned an up-coiler and pinch roll type feed rolls which may be used for guiding the leading end of the hot rolled strip into the up-coiler (Drawing A-1, left end of lower section). The up-coiler is used when it is desired to coil the strip after it leaves the 4-high mill on the last pass. The coiled strip is then removed from the up-coiler for further processing. If the hot rolled material is not to be coiled, the up-coiler deflector is raised above the roll table, and the material continues along the roll table under the up-coiler to the up-cut shear where it is cut to length, through the roller leveler and removed from the hot strip mill line by a transfer mechanism.

D. OPERATION

Broadly, the Crucible hot strip mill is used to produce hot rolled strip of a desired gauge and width within the capacity of the mill. The ingot is first reduced to a slab on the scalebreaker and roughing mills; the slab is conditioned and reheated; and the slab is then reduced in the scalebreaker, roughing and 4-high reversing mills to the hot rolled product of finish gauge. From April 1, 1949 to October 31, 1953 approximately 50 per cent of the material rolled was stainless steel or alloy steel, and 50 per cent was low or high carbon steel. Approximately 75 per cent of the material rolled in the 4-high reversing mill is coiled on all passes following the second pass through the reversing mill rolls in the manner to be described hereinafter, and 25 per cent is rolled "in the flat", i.e., with no coiling between any of the passes.

During a rolling operation in which the material being rolled is to be coiled between passes the material is rolled first in one direction, i.e., from north to south, and then in the reverse direction, i.e., from south to north. It is passed back and forth through the reducing rolls of the 4-high reversing mill until the final desired gauge is reached. During and after each of the passes various adjustments must be made in the apparatus in the 4-high reversing mill unit. These adjustments are made by actuation of electrical switches under the control of the men responsible for operating the mill. The controls will be described in detail hereafter.

Various changes and modifications that have been made in the apparatus of the 4-high mill unit since the original installation was placed in commercial operation have necessitated changes in the manner in which the apparatus is adjusted. For that reason a typical operation in the mill as originally operated commercially will be described, and the subsequent commercial operation of the mill for the modified installation will also be described.

Coiling Operation Under the Original Installation

As originally installed and operated, in the rolling of a breakdown to a finish gauge involving the coiling of the strip between passes the strip was not coiled on the south coiling reel adjacent the 4-high reversing mill after the first pass, but was rolled in the flat so as to reduce it in thickness sufficiently to permit of coiling it. Following the second pass through the reducing rolls, the material was coiled on the north coiling reel. Thereafter, the material was coiled and uncoiled on each pass, the material having been fed from each coil to the mill and coiled up on the other side as it issued. Coiling in one of the two coiler furnaces adjacent the 4-high mill continued up until the last pass, following which the strip was permitted to travel to the end of the run out table located south of the mill to either the up-coiler or cut to length on the up-cut shear (Drawing A-1, left end of lower section), the coiled or sheared material then having been taken away for further processing.

The following is the sequence of operations employed in the 4-high mill for rolling a breakdown to a finish gauge and employing coiling reels as described above.

First Pass (From North to South):

Before the first pass in the 4-high reversing mill, the mill unit was pre-set for the desired side guide width and mill roll spacing by the

operators. As the breakdown approached the 4-high reversing mill unit for the first pass the arrangement and operation of the apparatus of the mill unit was as follows (Drawing A-11, First Pass Started):

Mill Rolls:	Rotated at running speed in a direction to drive the strip from north to south.
North Side Guides:	Strip width and parallel.
South Side Guides:	Strip width plus 5″ and parallel.
Pinch Rolls:	High lift position.
Deflectors:	Down position.
Deflector Rolls:	Motor driven at slow idling speed.
Coiling Reels:	Rotated at slow idling speed.

Each of these parts functioned and remained in the status above described throughout the first pass and the strip was permitted to continue in the flat on the run-out table to the south of the 4-high reversing mill (Drawing A-11, First Pass Rolling). As the trailing end of the strip passed through the main mill rolls the mill was brought to a stop with the trailing end of the strip between the mill rolls and the south pinch rolls (Drawing A-11, First Pass Completed).

Second Pass (From South to North):

With the strip stopped at the mill, changes were made in the position of some of the apparatus of the mill unit in preparation for the second pass. The trailing end of the strip on the first pass became the leading end of the strip on the second pass. The guides were reset for the opposite direction of traverse. The mill was reversed by means of the Mill Master Switch and the second pass in which the strip moved from south to north began (Drawing A-2, Second Pass Started). On the second pass the strip was fed back through the mill rolls by frictional engagement with the driven table rolls. The mill rolls, table rolls, pinch rolls and deflector rolls turned at threading speed until the leading end of the strip had entered the north coiling reel slot. As set in preparation for the second pass the apparatus of the mill unit, including these changes, was as follows (Drawing A-12, Second Pass Started, Second Pass—Strip Entering Coiler on North Side):

Mill Rolls:	Brought closer together by operation of screw downs and rotated at threading speed to drive strip from south to north.
North Side Guides:	Strip width plus 5" and parallel.
South Side Guides:	Strip width and parallel.
Pinch Rolls:	High lift position (no change).
North Deflector:	Raised to up position to feed strip to coiler.
South Deflector:	Down position (no change).
North Deflector Roll:	Motor driven at threading speed.
South Deflector Roll:	Motor driven at threading speed.
North Coiling Reel:	Stopped with slot positioned to receive strip on second pass.
South Coiling Reel:	Rotated at slow idling speed (no change).

When the leading end of the strip had entered the north coiler, changes were made in the position of some of the mill unit apparatus. The apparatus, including these changes, was as follows (Drawing A-12, Second Pass During Rolling):

Mill Rolls:	Speed increased to running speed.
North Side Guides:	Strip width plus 5" and parallel (no change).
South Side Guides:	Strip width and parallel (no change).
North Pinch Rolls:	Lowered to low lift position.
South Pinch Rolls:	High lift position (no change).
North Deflector:	Lowered to down position.
South Deflector:	Down position (no change).
North Deflector Roll:	In contact with strip and motor driven at strip speed.
South Deflector Roll:	Motor driven at strip speed.

North Coiling Reel:	Rotated in clockwise direction to coil the strip.
South Coiling Reel:	Rotated at slow idling speed (no change).

The function and position of each of these parts remained the same throughout the second pass. The mill was stopped at the completion of the second pass with the trailing end of the strip between the main mill rolls and the north pinch rolls, the latter having been lowered to pinch position at this time to feed the strip back to the mill rolls on the succeeding pass (Drawing A-13, Second Pass Completed).

Third Pass (From North to South):

With the mill stopped, further changes were made in the apparatus in preparation for the third pass. The mill was again reversed by means of the Mill Master Switch and the third pass, from north to south, began. The mill unit, including these changes, was as follows (Drawing A-13, Third Pass Started):

Mill Rolls:	Brought closer together by operation of screw downs and rotated at threading speed to drive strip from north to south.
North Side Guides:	Strip width and parallel.
South Side Guides:	Strip width plus 5" and parallel.
North Pinch Rolls:	Pinch position to feed strip back to mill.
South Pinch Rolls:	High lift position (no change).
North Deflector:	Down position (no change).
South Deflector:	Raised to up position to feed strip to coiler.
North Deflector Roll:	In contact with strip and motor driven at threading speed.
South Deflector Roll:	Motor driven at threading speed.
North Coiling Reel:	Rotated to unwind strip at threading speed.
South Coiling Reel:	Stopped with slot positioned to receive strip on third pass.

After the leading end of the strip had passed between the main mill rolls the north pinch rolls were raised to the low lift position (Drawing A-13, Third Pass Entering South Coiler). When the leading end of the strip entered the south coiler, changes in the apparatus were made, and the mill unit was as follows (Drawing A-14, Third Pass Rolling):

Mill Rolls:	Speed increased to running speed.
North Side Guides:	Strip width and parallel (no change).
South Side Guides:	Strip width plus 5" and parallel (no change).
North Pinch Rolls:	Low lift position.
South Pinch Rolls:	Lowered to low lift position.
North Deflector:	Down position (no change).
South Deflector:	Lowered to down position.
North Deflector Roll:	In contact with strip and motor driven at strip speed.
South Deflector Roll:	In contact with strip and motor driven at strip speed.
North Coiling Reel:	Rotated to unwind strip at mill operating speed.
South Coiling Reel:	Rotated in counterclockwise direction to coil the strip.

The function and position of each of these parts remained the same throughout the third pass. The mill was stopped at the completion of the pass with the trailing end of the strip between the main mill rolls and the south pinch rolls, the latter having been lowered to pinch position at this time to feed the strip back to the mill rolls on the succeeding pass (Drawing A-14, Third Pass Completed).

Fourth Pass (From South to North):

Again, with the mill stopped further changes were made in the position of the apparatus in preparation for the fourth pass. The mill was again reversed by means of the Mill Master Switch and the fourth

pass, from south to north, began. The mill unit then appeared as follows (Drawing A-14, Fourth Pass Started):

Mill Rolls:	Brought closer together by operation of screw downs and rotated at threading speed to drive the strip from south to north.
North Side Guides:	Strip width plus 5" and parallel.
South Side Guides:	Strip width and parallel.
North Pinch Rolls:	Raised to high lift position.
South Pinch Rolls:	Pinch position to feed strip back to mill.
North Deflector:	Raised to up position to feed strip to coiler.
South Deflector:	Down position (no change).
North Deflector Roll:	Motor driven at threading speed.
South Deflector Roll:	In contact with strip and motor driven at threading speed.
North Coiling Reel:	Stopped with slot positioned to receive strip on fourth pass.
South Coiling Reel:	Rotated to unwind strip at threading speed.

After the leading end of the strip had passed between the mill rolls the south pinch rolls were raised to the low lift position (Drawing A-15, Fourth Pass Entering North Coiler). When the leading end of the strip entered the north coiler additional changes were made in the position of the apparatus and the mill was as follows (Drawing A-15, Fourth Pass Rolling):

Mill Rolls:	Speed increased to running speed.
North Side Guides:	Strip width plus 5" and parallel (no change).
South Side Guides:	Strip width and parallel (no change).
North Pinch Rolls:	Lowered to low lift position.
South Pinch Rolls:	Low lift position.

North Deflector:	Lowered to down position
South Deflector:	Down position (no change).
Deflector Rolls:	In contact with strip and motor driven at strip speed.
North Coiling Reel:	Rotated in clockwise direction to coil the strip.
South Coiling Reel:	Rotated to unwind strip at mill operating speed.

The function and position of each of these parts remained the same throughout the fourth pass. The mill was stopped at the completion of the fourth pass with the trailing end of the strip between the mill rolls and the north pinch rolls, and at this time the north pinch rolls were lowered to pinch position to feed the strip back to the mill on the succeeding pass (Drawing A-15, Fourth Pass Completed).

Succeeding Passes Including Last Pass

The strip received five or seven passes in the 4-high reversing mill in normal operation, depending upon the material being rolled and the final desired thickness. If the strip was to receive seven passes, the strip was coiled on the south coiling reel after the fifth pass in a manner similar to the third pass as described. Similarly, on the sixth pass the strip was coiled on the north coiling reel and the pass was made in the same manner as the fourth pass.

After the mill was stopped on the next to the last pass with the strip coiled on the north coiling reel, in addition to lowering the north pinch rolls to pinch position, further changes were made in the position of the apparatus of the mill unit in preparation for the last pass. The mill was again reversed by means of the Mill Master Switch and the last pass from north to south began. Threading speed was not used on the last pass. At this time the mill unit was as follows (Drawing A-16, Final Pass Started):

Mill Rolls:	Brought to final gauge position by operation of the screw downs, and rotated at running speed to drive strip from north to south.
North Side Guides:	Strip width and parallel.
South Side Guides:	Strip width plus 5″ and parallel.

North Pinch Rolls:	Pinch position.
South Pinch Rolls:	Raised to high lift position.
North Deflector:	Down position (no change).
South Deflector:	Down position (no change).
North Deflector Roll:	In contact with strip and motor driven at strip speed.
South Deflector Roll:	Motor driven at strip speed.
North Coiling Reel:	Rotated to unwind strip at mill operating speed.
South Coiling Reel:	Rotated slowly at idling speed.

The leading end of the strip passed through the main mill rolls, beneath the south coiler furnace and on out the run-out tables. After the leading end of the strip had passed through the main mill rolls the north pinch rolls were raised to low lift position, and the function and position of the apparatus remained the same throughout the last pass (Drawing A-16, Final Pass During Rolling).

After the last pass the apparatus of the 4-high reversing mill unit was re-set by means of electric switches in preparation for rolling the next breakdown and the operation as described was repeated.

Coiling Operation Under the Modified Installation

The principal modifications and changes in the 4-high reversing mill unit that have been made since the mill was placed in commercial operation and that materially alter the operation of the mill are:

(1) Installation of the auxiliary or hold-down roll (*ante*, pp. 9-10), and removal of the intermediate or low lift position from the pinch rolls (*ante*, pp. 8-9).

(2) Installation of the magnetic clutch for intermittent actuation of the deflector roll drive (*ante*, pp. 11-12, *post*, pp. 35-36).

(3) Side guide actuation: several modifications made as explained (*post*, pp. 30-32).

As in the original installation (*ante*, p. 13) the strip is not coiled on the south coiling reel after the first pass but is rolled in the flat so as to reduce it in thickness sufficiently to permit of coiling it. Following the second pass through the reducing rolls the material is coiled on the

north coiling reel. Thereafter the material is coiled and uncoiled on each pass, the material being fed from each coil to the mill and coiled up on the other side as it issues. Coiling in one of the two coiling furnaces adjacent the 4-high mill continues up until the last pass, following which the strip is permitted to travel to the end of the run-out table located south of the mill to either the up-coiler or cut to length on the up-cut shear. The coiled or sheared material is then removed for further processing. As in the original installation the mill unit is pre-set by the mill operator depending upon the width and gauge of the material to be rolled.

First Pass (From North to South):

As the breakdown approaches the 4-high reversing mill unit for the first pass the positioning of the apparatus of the mill unit is as follows (Drawing A-17, First Pass Started):

Mill Rolls:	Rotating at running speed in a direction to drive strip from north to south.
North Side Guides:	Strip width and parallel.
South Side Guides:	Strip width plus 5" and parallel.
Pinch Rolls:	Up position.
Hold Down Rolls:	Up position.
Deflectors:	Down position.
Deflector Rolls:	Motor driven at strip speed.
Coiling Reels:	Rotating at slow idling speed.

Each of these parts functions and remains in the positions described throughout the first pass and the strip is permitted to continue in the flat on the run-out table to the south of the 4-high reversing mill (Drawing A-17, First Pass Rolling). As the trailing end of the strip passes through the main mill rolls, the mill is brought to a stop with the trailing end of the strip between the mill rolls and the south pinch rolls (Drawing A-17, First Pass Completed).

Second Pass (From South to North):

With the strip stopped at the mill, changes are made in the position of some of the apparatus of the mill unit in preparation for the second pass. The mill is reversed by means of the Mill Master Switch and the

second pass in which the strip moves from south to north commences. On the second pass the strip is fed back through the mill rolls by frictional engagement with the driven table rolls. The mill rolls, table rolls, pinch rolls and south deflector roll turn at threading speed until the leading end of the strip has entered the north coiling reel slot. As set in preparation for the second pass the operation of the mill unit, including these changes, is as follows (Drawing A-18, Second Pass Started; Second Pass—Strip Entering Coiler on North Side):

Mill Rolls:	Brought closer together by operation of screw downs and rotating at threading speed to drive strip from south to north.
North Side Guides:	Strip width plus 5″ and parallel.
South Side Guides:	Strip width and parallel.
Pinch Rolls:	Up position (no change).
Hold Down Rolls:	Up position (no change).
North Deflector:	Raised to up position to feed strip to coiler.
South Deflector:	Down position (no change).
North Deflector Roll:	Not turning.
South Deflector Roll:	Motor driven at strip speed.
North Coiling Reel:	Stopped with slot positioned to receive strip on second pass.
South Coiling Reel:	Rotating at slow idling speed (no change).

When the leading end of the strip has entered the north coiler, changes are made in the position of some of the mill unit apparatus. The apparatus, including the changes, is as follows (Drawing A-18, Second Pass During Rolling):

Mill Rolls:	Speed increased to running speed.
North Side Guides:	Strip width plus 5″ and parallel (no change).
South Side Guides:	Strip width and parallel (no change).

Pinch Rolls:	Up position (no change).
North Hold Down Roll:	Lowered to down position.
South Hold Down Roll:	Up position (no change).
North Deflector:	Lowered to down position.
South Deflector:	Down position (no change).
North Deflector Roll:	In contact with strip and turned by frictional force of strip.
South Deflector Roll:	Motor driven at strip speed (no change).
North Coiling Reel:	Rotated in clockwise direction to coil the strip.
South Coiling Reel:	Rotating at slow idling speed (no change).

The function and position of each of these parts remain the same throughout the second pass. The mill is stopped at the completion of the second pass with the trailing end of the strip between the main mill rolls and the north pinch rolls, the latter being lowered at this time to pinch position to feed the strip back to the mill rolls on the succeeding pass (Drawing A-19, Second Pass Completed).

Third Pass (From North to South):

With the mill stopped further changes are made in the apparatus in preparation for the third pass. The mill is again reversed by means of the Mill Master Switch and the third pass, from north to south, begins. The mill unit, including these changes, is as follows (Drawing A-19, Third Pass Started):

Mill Rolls:	Brought closer together by operation of screw downs and rotating at threading speed to drive strip from north to south.
North Side Guides:	Strip width and parallel.
South Side Guides:	Strip width plus 5" and parallel.
North Pinch Rolls:	Pinch position to feed strip back to mill.
South Pinch Rolls:	Up position (no change).

North Hold Down Roll:	Down position (no change).
South Hold Down Roll:	Up position (no change).
North Deflector:	Down position (no change).
South Deflector:	Raised to up position to feed strip to coiler.
North Deflector Roll:	In contact with strip and turned by frictional force of strip.
South Deflector Roll:	Not turning.
North Coiling Reel:	Rotated to unwind strip at threading speed.
South Coiling Reel:	Stopped with slot positioned to receive strip on third pass.

As soon as the leading end of the strip has passed between the main mill rolls the north pinch rolls are raised to up position (Drawing A-19, Third Pass Entering South Coiler). When the leading end of the strip has entered the south coiler further changes in the position of the apparatus are made, and the apparatus is as follows (Drawing A-20, Third Pass Rolling):

Mill Rolls:	Speed increased to running speed.
North Side Guides:	Strip width and parallel (no change).
South Side Guides:	Strip width plus 5" and parallel (no change).
North Pinch Rolls:	Up position.
South Pinch Rolls:	Up position (no change).
North Hold Down Roll:	Down position (no change).
South Hold Down Roll:	Lowered to down position.
North Deflector:	Down position (no change).
South Deflector:	Lowered to down position.
North Deflector Roll:	In contact with strip and turned by frictional force of strip.

South Deflector Roll:	In contact with strip and turned by frictional force of strip.
North Coiling Reel:	Rotated to unwind strip at mill operating speed.
South Coiling Reel:	Rotated in counter-clockwise direction to coil the strip.

The function and position of each of these parts remain the same throughout the third pass. The mill is stopped at the completion of the pass with the trailing end of the strip between the main mill rolls and the south pinch rolls, the latter being lowered to pinch position at this time to feed the strip back to the mill on the succeeding pass (Drawing A-20, Third Pass Completed).

Fourth Pass (From South to North):

Again, with the mill stopped further changes are made in preparation for the fourth pass. The mill is again reversed by means of the Mill Master Switch and the fourth pass from south to north begins. The mill is then as follows (Drawing A-20, Fourth Pass Started):

Mill Rolls:	Brought closer together by operation of screw downs and rotated at threading speed to drive the strip from south to north.
North Side Guides:	Strip width plus 5" and parallel.
South Side Guides:	Strip width and parallel.
North Pinch Rolls:	Up position (no change).
South Pinch Rolls:	Pinch position to feed strip back to mill.
North Hold Down Roll:	Raised to up position.
South Hold Down Roll:	Down position (no change).
North Deflector:	Raised to up position to feed strip to coiler.
South Deflector:	Down position (no change).
North Deflector Roll:	Not turning.

South Deflector Roll:	In contact with strip and turned by frictional force of strip.
North Coiling Reel:	Stopped with slot positioned to receive strip on fourth pass.
South Coiling Reel:	Rotated to unwind strip at threading speed.

After the leading end of the strip has passed between the main mill rolls the south pinch rolls are raised to up position (Drawing A-21, Fourth Pass Entering North Coiler). When the leading end of the strip has entered the north coiler additional changes are made in the position of the apparatus and the mill is as follows (Drawing A-21, Fourth Pass Rolling):

Mill Rolls:	Speed increased to running speed.
North Side Guides:	Strip width plus 5" and parallel (no change).
South Side Guides:	Strip width and parallel (no change).
North Pinch Rolls:	Up position (no change).
South Pinch Rolls:	Up position.
North Hold Down Roll:	Lowered to down position.
South Hold Down Roll:	Down position (no change).
North Deflector:	Lowered to down position.
South Deflector:	Down position (no change).
Deflector Rolls:	In contact with strip and turned by frictional force of strip.
North Coiling Reel:	Rotated in clockwise direction to coil the strip.
South Coiling Reel:	Rotated to unwind strip at mill operating speed.

The function and position of each of these parts remain the same throughout the fourth pass. The mill is stopped at the completion of the fourth pass with the trailing end of the strip between the mill rolls

and the north pinch rolls, and at this time the north pinch rolls are lowered to pinch position to feed the strip back to the mill on the succeeding pass (Drawing A-21, Fourth Pass Completed).

Succeeding Passes Including Last Pass

As in the original installation the strip may receive either five or seven passes. The strip, which will move in a direction of north to south on the last pass is not coiled on the south coiling reel on the last pass but continues along the run-out tables to the up-coiler or up-cut shear at the south end of the mill line.

After the mill has been stopped on the next to the last pass with the strip coiled on the north coiling reel, in addition to lowering the north pinch rolls to pinch position, further changes are made in apparatus of the mill unit in preparation for the last pass. The mill is again reversed by means of the Mill Master Switch and the last pass from north to south begins. Threading speed is not used on the last pass. At this time the mill unit is as follows (Drawing A-22, Final Pass Started):

Mill Rolls:	Brought to final gauge position by operation of screw downs and rotating at running speed to drive the strip from north to south.
North Side Guides:	Strip width and parallel.
South Side Guides:	Strip width plus 5″ and parallel.
North Pinch Rolls:	Pinch position to feed strip back to mill.
South Pinch Rolls:	Up position (no change).
North Hold Down Roll:	Down position (no change).
South Hold Down Roll:	Raised to up position.
North Deflector:	Down position (no change).
South Deflector:	Down position (no change).
North Deflector Roll:	In contact with strip and turned by frictional force of strip.
South Deflector Roll:	Motor driven at strip speed.

North Coiling Reel:	Rotating to unwind strip at mill operating speed.
South Coiling Reel:	Rotated slowly at idling speed.

After the leading end of the strip has passed through the main mill rolls the north pinch rolls are raised to the up position, and the function and position of the apparatus remain the same throughout the last pass (Drawing A-22, Final Pass During Rolling).

After the last pass the apparatus of the 4-high reversing mill unit is reset in preparation for rolling the next breakdown and the operation as described is repeated.

Non-Coiling Operation in Original and Modified Installations

As previously noted (*ante*, p. 12), approximately 25 per cent of the rolling in the 4-high reversing mill is performed in the flat, i.e., with no coiling between the reducing passes. This flat rolling operation is the same for the modified operation as it was in the original installation. The material is fed to the 4-high reversing mill from the roughing mill and passed back and forth through the reducing rolls of the 4-high mill in the flat condition until the final desired gauge is reached. No use is made of the deflectors, coiling reels, deflector rolls, pinch rolls or auxiliary rolls in the flat rolling operation. The side guides are used to align the strip as in a coiling pass. The frictional contact between the material being rolled and the rolls of the roll table is sufficient to feed the strip into the reducing rolls of the mill. When the desired gauge is reached the material is passed along the run-out table where it is sheared, levelled and removed by the transfer mechanism (Drawing A-1, left end of lower section).

E. CONTROLS

The Crucible hot strip mill is electrically controlled, and is under the immediate supervision of a foreman, called the Roller. The scale-breaker mill is under the control of one operator. The roughing mill is under the control of two operators, one controlling the horizontal rolls and one controlling the vertical edger. The 4-high reversing mill unit is under the control of an Operator and an Assistant Operator. In addition, there are several other workmen essential to the overall operation of the hot strip mill.

There are two control panels for controlling the 4-high reversing mill unit, one designated the "Operator's Desk Panel" (Drawing A-24) which is located in a pulpit a short distance from the hot strip mill line and opposite the north coiler furnace, and the other designated the "Assistant Operator's Desk Panel" (Drawing A-25) which is located in a pulpit opposite the south coiler furnace. The Operator occupies the north pulpit and the Assistant Operator the south pulpit. The panels (Drawings A-24 and A-25) include controls for actuating the various components of the 4-high reversing mill unit, i.e., the screw downs, the mill rolls, side guides, pinch rolls, auxiliary or hold-down rolls, deflectors, deflector rolls, coiling reels, scale removal sprays and the table rolls in the immediate vicinity of the 4-high reversing mill unit.

By means of these controls the apparatus of the 4-high reversing mill unit is properly positioned prior to and during the rolling operation. The actuation of the apparatus will now be described.

4-High Mill Stand and Mill Rolls

The spacing of the driven working rolls of the 4-high mill is controlled by the Operator from the north pulpit. These rolls are pre-set by the screw downs for the first pass and between succeeding passes the rolls are brought closer together until the final gauge desired is reached.

The speed and direction of rotation of the rolls and the resulting rate of travel of the strip is controlled by the Operator. Certain of the apparatus of the 4-high reversing mill unit is tied in with the mill speed control, i.e., the direction and speed of rotation of the table rolls, pinch rolls and coilers must be coordinated with the direction and speed of rotation of the mill rolls during the rolling operation.

The Operator regulates the speed and direction of travel from his panel through the Mill Master Switch (Drawing A-24). This switch has five possible positions. These are (1) "Off", at which position the mill, table rolls, pinch rolls and coilers are stopped; (2) and (3) "Threading" (either left or right), at which positions the mill rolls, etc., will turn at a speed of from 250 to 450 feet per minute, and which are used during a coiling pass when the leading end of the strip is being fed into the mill rolls and until the strip has been secured through one or two turns on either coiling reel; and (4) and (5) "Running" (either left or right), at which positions the mill rolls and other equipment

turn at a speed of from 300 to 1200 feet per minute, and which are used after the strip has been secured to either coiling reel, on the last pass, or at all times during the running of a flat pass. The particular threading or running speed desired is controlled by independent setting of the Thread Speed Selector Switch or Running Spped Selector Switch (Drawing A-24).

In addition to controlling the speed and direction of travel of the strip, the actuation of the parallel side guides to their proper entry or delivery positions may be tied in by automatic control to the Mill Master Switch in the manner to be described hereinafter. The side guides also may be actuated by independent push button control.

In addition to the Mill Master Switch on the Operator's control panel, the Assistant Operator has access to a Mill Stop Button (Drawing A-25). In the event of any electrical, mechanical or operational failure during rolling, and if the Operator fails to stop the mill with the Mill Master Switch, the Assistant Operator may actuate his Mill Stop Button and completely de-energize the mill.

Side Guides

Each set of guides immediately adjacent the 4-high reversing mill stand is adjusted in and out by m ans of an independent reversibly driven motor through a threaded shaft and gearing arrangement. Prior to the running of a particular width of strip in the 4-high reversing mill each set of guides is preset from the desk panels by actuation of the Side Guide Adjustment Switch (Drawings A-24 and A-25) so that when functioning as entry guides the guides will be at approximately strip width with their opposing faces parallel one to the other. When functioning as delivery guides they will be strip width plus five inches with their opposing faces parallel (Drawing A-23). The limiting adjustments of each set of guides to the entry or delivery position by actuation of the independent guide motors is effected by means of a limit switch. This limit switch contains a pair of cam actuated contacts which are preset for limiting the entry and delivery positions of each pair of guides to that desired for the width of strip being rolled.

The actuation of these side guides has been effected in several different ways since the Crucible hot strip mill was placed in commercial operation in April of 1949. For approximately one year thereafter, each set of guides was operated independently of the other. A side guide operator was stationed on each side of the mill, and by means of

lever actuated electrical control circuits, would adjust the guides on his side in or out depending on the direction of travel of the strip. Both sets of guides also could be operated by one side guide operator. This method of operation will be referred to as the "independent manual" side guide control.

In January of 1950 control of the guides was tied in with the Mill Master Switch in such manner that when the Master Switch was positioned to energize the mill to move the strip from right to left (north to south), the north guides would serve as entry guides and would move to entry position, and the south guides would serve as delivery guides and would move to delivery position. When the Mill Master Switch was positioned to energize the mill to move the strip from left to right (south to north) the function and position of the guides would automatically reverse, i.e., the south guides would move to the entry position and the north guides to the delivery position. The two independent side guide motors were arranged to be oppositely driven for any given side guide adjustment. Thus, when one guide motor was energized to adjust its guides inwardly to assume entry position, the other guide motor was energized to concurrently adjust its guides in the opposite direction, i.e., outwardly to assume delivery position. Under this arrangement, which will be referred to as the "direct actuation-automatic" side guide control, the guides would not move to their proper positions for a given pass until the mill had been energized to move the strip in the direction for which the Mill Master Switch was set. This method of guide adjustment proved unsatisfactory since the guides and the strip were concurrently in motion, the guides therefore being ineffective and productive of jamming of the strip in the guides.

For this reason the mode of controlling and adjusting the guides was further modified in the summer of 1950. This modification, in which actuation of the guides was also tied in with the Mill Master Switch, served to effect movement of the side guides to their appropriate positions for the next pass automatically after the mill had been brought to a stop, and before the strip began to move on the next succeeding pass. With this modification, which will be referred to as the "anticipatory-automatic" side guide control, adjustment of the guides was effected only with the Mill Master Switch in the "Off" position. Thus, for the first pass through the 4-high reversing mill the north guides will have been set as entry guides (strip width) and the south guides will have been set as delivery guides (strip width plus five inches). During the first pass the Mill Master Switch is positioned

to energize the mill to move the breakdown from right to left through the mill. As the strip completes its first pass the Mill Master Switch is moved to "Off" position, deenergizing the mill to arrest further movement of the breakdown. Placing the Mill Master in the "Off" position, energizes electrical relay circuits to adjust both sets of guides automatically and simultaneously to their opposite limits, i.e., the guides serving as delivery guides on the first pass move in to the entry guide position and the guides serving as entry guides on the first pass move out to delivery guide position. This rearrangement of the guides for the second pass is thus completed prior to energizing the mill motor to move the strip from left to right (south to north) on the second pass. With the Mill Master Switch in position to move the strip from left to right the guides remain locked in their proper positions throughout the pass. As the strip completes its second pass the Master Switch is again placed on "Off" position to stop the mill and the side guides are thereby automatically adjusted to their opposite positions properly to guide the strip for its third pass from right to left.

On January 21, 1952, a still further modification was completed in the side guide control system. This modification involved the installation of manually actuated push button controls, and will be referred to as the "push button" side guide control. With the side guides operating by push button control, actuation of the guides from one limit position to the other is normally effected only when the Mill Master Switch is in "Off" position. The Mill Guides Button (Drawing A-25) is then depressed. This actuation, like that described for the "anticipatory automatic" side guide control, also occurs prior to commencement of movement of the strip. Thus, when the strip has been running from right to left and the Mill Master Switch is moved to "Off" position, the Mill Guides Button is depressed and the south guides will change from delivery to entry position and the north guides will change from entry to delivery position. The succeeding pass will then be started. Each pair of guides remains in its respective position until the next succeeding time the Mill Guides Button is depressed after the Mill Master Switch is returned to "Off" position, at which time the function and position of each pair of guides will be reversed by depressing the Mill Guides Button. The Assistant Operator operates the "push button" side guide control from the south pulpit irrespective of the direction of rolling in the mill.

Interchange between the last two modifications ("anticipatory automatic" and "push button") of the side guide control system may be made by throwing a gang switch located on a separate switch panel.

Pinch Rolls and Hold-Down Rolls

As originally installed each of the top pinch rolls could be actuated to any one of its three positions by means of a manually operated rotary electric switch. The switch for operating the north upper pinch roll was located on the Operator's control desk. The Assistant Operator controlled the south upper pinch roll from his control desk. Each pinch roll control switch was rotatable to any one of three actuating positions: "High Lift", "Low Lift" and "Pinch." Each switch position was connected by suitable electrical circuits to solenoid actuated air valves which in operation selectively introduced or exhausted air from the various pinch roll air cylinder and piston assemblies to bring the top roll to its proper position.

In the modified pinch roll and hold-down roll assembly, installation and testing of which was completed on October 29, 1951, actuation of the upper pinch roll to the proper one of its two possible positions ("up" or "pinch"), or the hold-down roll to the proper one of its two possible positions ("up" or "down"), is also effected by a manually operated rotary switch for each pinch and hold-down roll assembly, the Operator controlling the north side and the Assistant Operator the south side. Each switch may be rotated to any one of four actuating positions. In the first position the upper pinch roll and hold-down roll are lowered to their lowermost positions—pinch position for the upper pinch roll and 3 inches above the material pass line for the hold-down roll. In its second position the upper pinch roll and hold-down roll are raised to their uppermost positions, 12 inches above the material pass line. In the third position the upper pinch roll alone is lowered to its pinch position and the hold-down roll either remains in or returns to its uppermost position. In the fourth position the hold-down roll is lowered to its lowermost position and the upper pinch roll either remains in or returns to its uppermost position. Thus, by proper positioning of this selector switch both the pinch and hold-down rolls may be elevated or lowered to all possible positions either concurrently or selectively. The selector switch may be moved from any of its four positions to any other of its four positions as desired. Each selector switch position is connected to suitable relay circuits for selectively actuating a solenoid controlled air valve for actuation of the pinch roll and a solenoid controlled hydraulic valve for actuation of the hold-down roll.

Coiling Reels

Each of the coiling reels of the 4-high reversing mill unit is electrically driven by means of two 150 horsepower reversible motors. As originally installed one 150 horsepower motor was used to drive each reel. In July of 1953 an additional 150 horsepower motor was added to each coiling reel. The north coiling reel is controlled by the Operator and the south coiling reel is controlled by the Assistant Operator. Each coiling reel is actuated by two control switches, the Coiler Selector Switch and the Coiler Master Switch (Drawings A-24 and A-25).

Each Coiler Selector Switch has four possible positions. These positions and the resulting actuation of the coiling reel are as follows:

(1) "Off". This position is used to stop the coiling reel.

(2) "Idle". With the Coiler Selector Switch placed in the "Idle" position the coiling reel will turn at a slow idling speed. This position of the Coiler Selector Switch is used when the coiling reels are not being utilized—when the strip is being rolled in the flat without coiling between passes, or when no strip is being rolled in the 4-high reversing mill. Both Coiler Selector Switches occupy this position during the initial pass from north to south in the 4-high reversing mill.

(3) "Normal". The Coiler Selector Switch is placed in the "Normal" position during a rolling and coiling operation. The Coiler Selector Switch will remain in "Normal" position throughout the remaining rolling and coiling passes. The second coiling reel control switch, called the Coiler Master Switch, is used in conjunction with the Coiler Selector Switch during this period. The Coiler Master Switch has two possible positions—"Off" and "On"—and is effective only when the Coiler Selector Switch is in the "Normal" position. At this time the Coiler Master Switch, when placed in "Off" position, stops the coiling reel with its mouth ready to receive the leading end of the strip at the beginning of a coiling pass. With the Coiler Selector Switch remaining in "Normal" position, the Coiler Master Switch, when moved to its "On" position, will cause the coiling reel to rotate at a speed and in a direction commensurate with the speed of the main mill rolls as controlled by the Operator through the Mill Master Switch (*ante*, pp. 29-30).

When the Coiler Selector Switch is in "Normal" position the magnetic clutch of the deflector roll drive is disengaged and the deflector

roll functions as a non-driven idler roll, being turned, when in contact with the strip, by frictional engagement with the strip.

(4) "Jog". As originally operated the Coiler Selector Switch was placed in the "Jog" position when it was desired to move the coiling reel around by small increments. Jogging the reel (moving it around little by little) is now accomplished by making and breaking the circuit at the "Idle" control point of the Coiler Selector Switch.

The motor drives of the coiling reels are so controlled as to tend to drive the winding reel at a slightly greater peripheral speed than that of the mill rolls, and thereby apply tension to the strip between the winding reel and the mill rolls. Similarly, the drive of the unwinding reel is such as to exert a slight tension on the strip between the unwinding reel and the mill rolls.

Deflector Rolls

In the original installation each of the deflector rolls of the 4-high reversing mill unit was an idler roll and was turned only by frictional force resulting from contact with the strip during a coiling operation. The original installation was modified shortly after operations began, and as modified each deflector roll was motor driven by a low horsepower motor. During a coiling operation the rolls were motor driven in a direction and at a speed which conformed to the direction and speed of the main mill rolls. At other times the rolls were motor driven slowly at idling speed to prevent warping (*ante*, p. 11).

In November, 1951 a disengageable magnetic clutch was incorporated in each of the deflector roll drives. During a coiling operation the magnetic clutch is disengaged and the deflector rolls are not motor driven but are turned only by frictional engagement with the strip as it is wound and unwound from the coiling reels. At all other times the magnetic clutch is engaged and the deflector rolls are motor driven. The deflector rolls are inter-connected through an electrical circuit to the switches controlling the table rolls. When the table roll control switches are actuated to start, stop, accelerate or decelerate the table rolls, the deflector rolls also start, stop, accelerate or decelerate.

An inter-connection through an electrical circuit between the deflector roll drive and the coiling reel controls causes the magnetic clutch of the deflector roll motor to disengage when the Coiler Selector

Switch is placed in the "Normal" position. In this position, used during a coiling operation, the deflector rolls are driven only as a result of frictional engagement with the strip, and a change in the table roll control switches does not affect the deflector rolls.

Roll Tables

The table rolls of the roll table in the immediate vicinity of the 4-high reversing mill unit may be actuated independently of the Mill Master Switch, as is the case when no strip is running in the mill, or may be actuated by the Mill Master Switch during the rolling operation. When actuated independently, these rolls will turn slowly at idling speed. When actuated by tie-in with the Mill Master Switch the direction and speed at which the table rolls turn depend on the direction and speed at which the main mill rolls turn.

Deflector

Each of the deflectors is actuated by a hydraulic cylinder, controlled by a Gate switch on the Assistant Operator's Desk Panel (Drawing A-25). This switch may occupy one of three positions: (1) "South Up", in which position the south deflector is in its raised position to feed the strip into the south coiling reel; (2) "Down", in which position both deflectors are down; and (3) "North Up", in which position the north deflector is in its raised position to feed the strip into the north coiling reel. As originally installed the Operator's desk was fitted with a Gate control (Drawing A-24) and the north deflector was actuated by the Operator. Shortly after commercial operation commenced, however, and the work load of each of the operators was established, the Gate control switch on the Assistant Operator's Desk was tied into the north deflector and both deflectors were actuated by the Assistant Operator.

Water and Steam Sprays

The water and steam spray positioned north of the north coiling reel, and used only as the strip approaches the 4-high mill on the first pass, is actuated by the Water and Steam switches under the control of the Assistant Operator in the south pulpit (Drawing A-25).

EXHIBIT D-6

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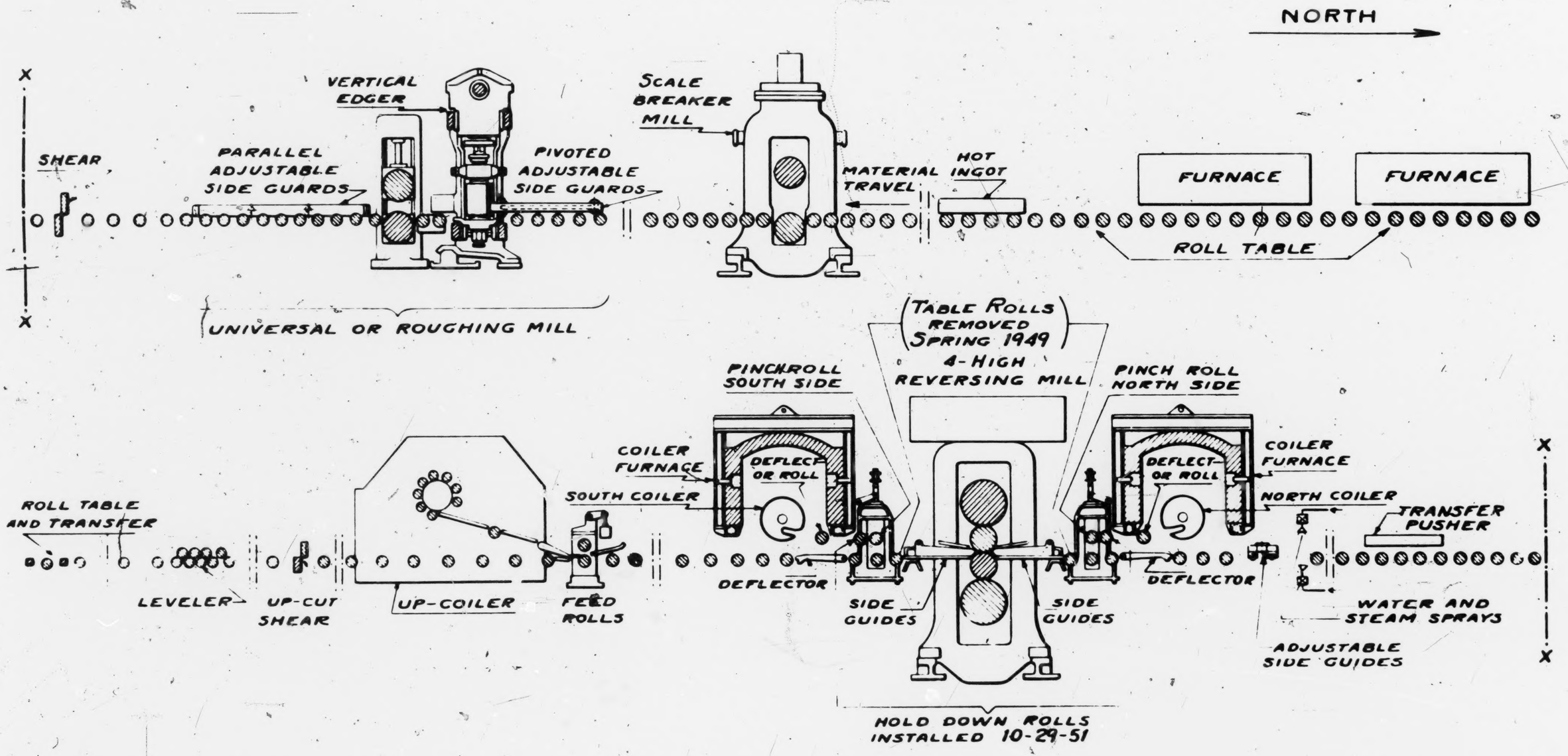
CRUCIBLE HOT STRIP MILL
DIAGRAMMATIC SECTION OF COMPLETE MILL

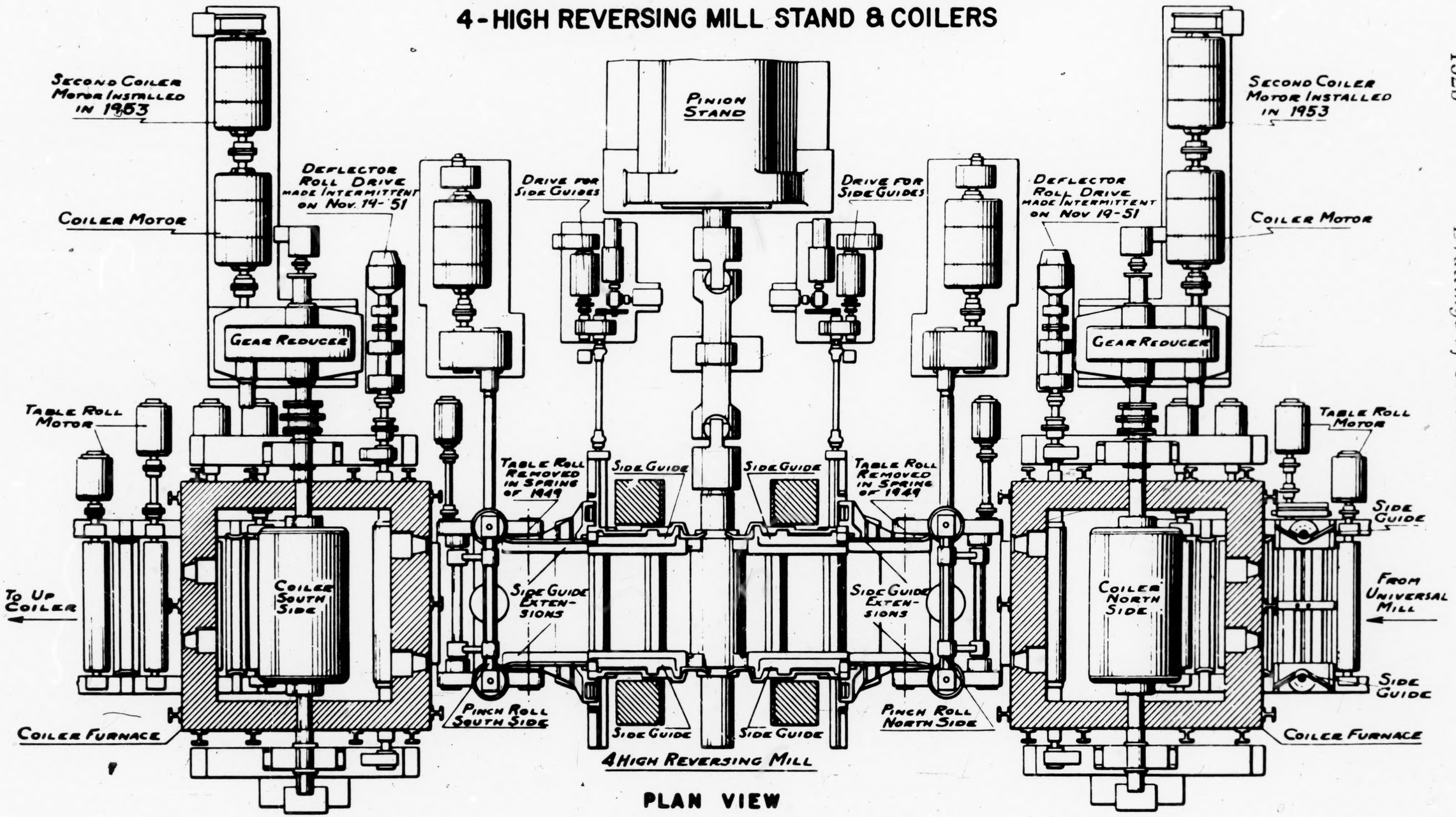


Drawings of Crucible Mill

131b

CRUCIBLE HOT STRIP MILL

4-HIGH REVERSING MILL STAND & COILERS

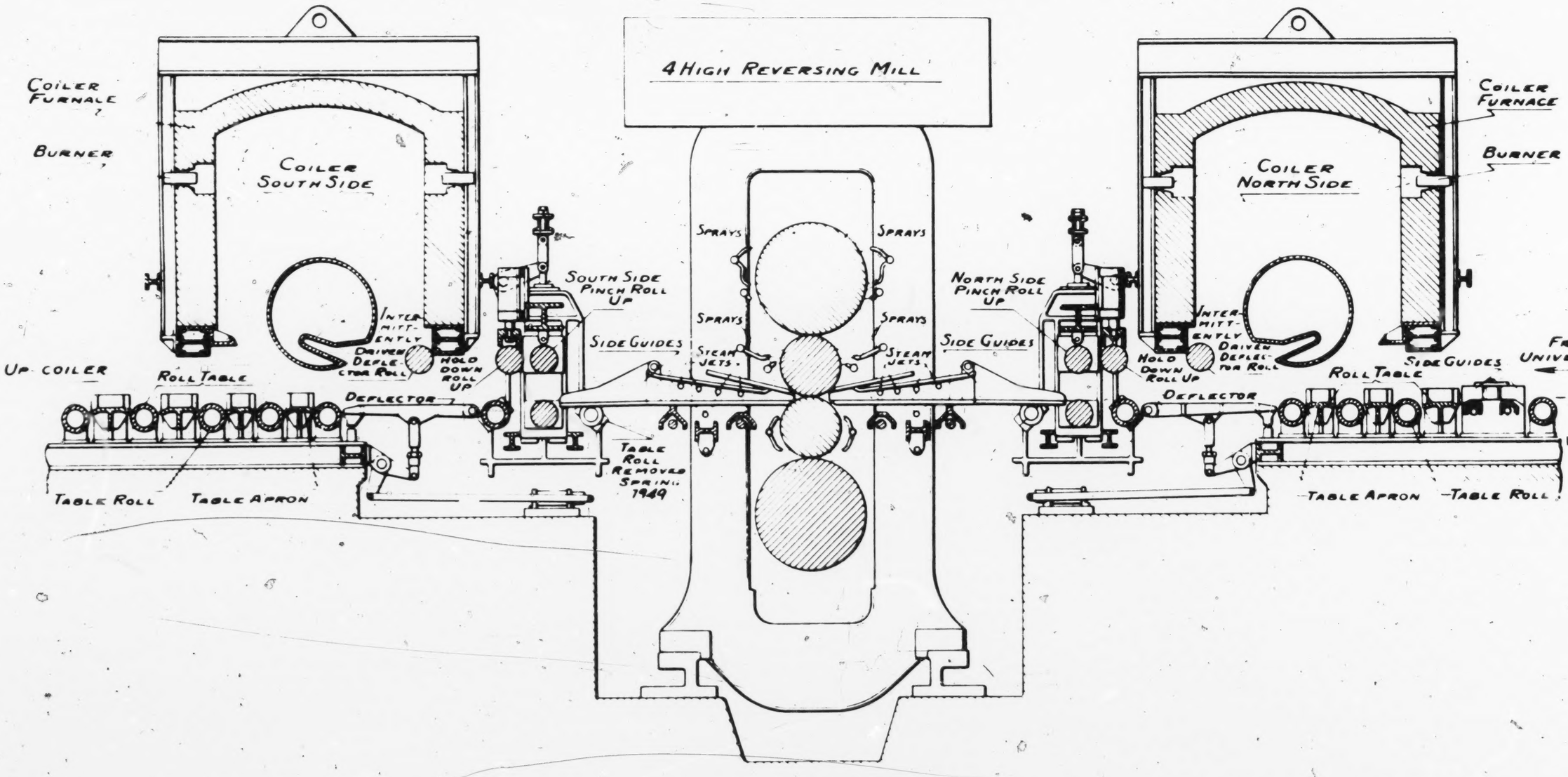


PLAN VIEW

CRUCIBLE HOT STRIP MILL

4-HIGH REVERSING MILL STAND & COILERS

MODIFIED INSTALLATION



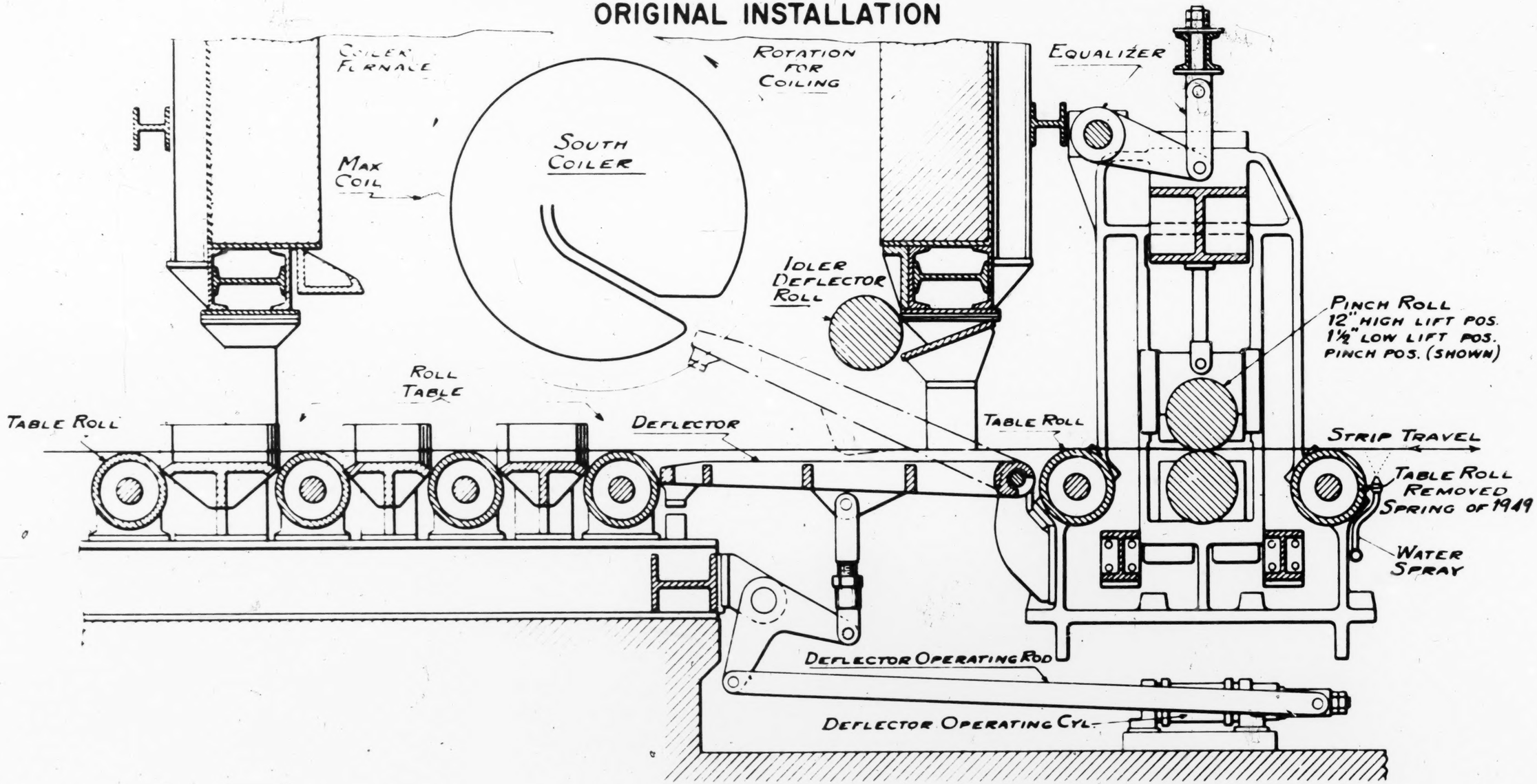
VERTICAL SECTION

Drawings of Crucible Mill 133b

CRUCIBLE HOT STRIP MILL

VERTICAL SECTION AT PINCH ROLL & COILER

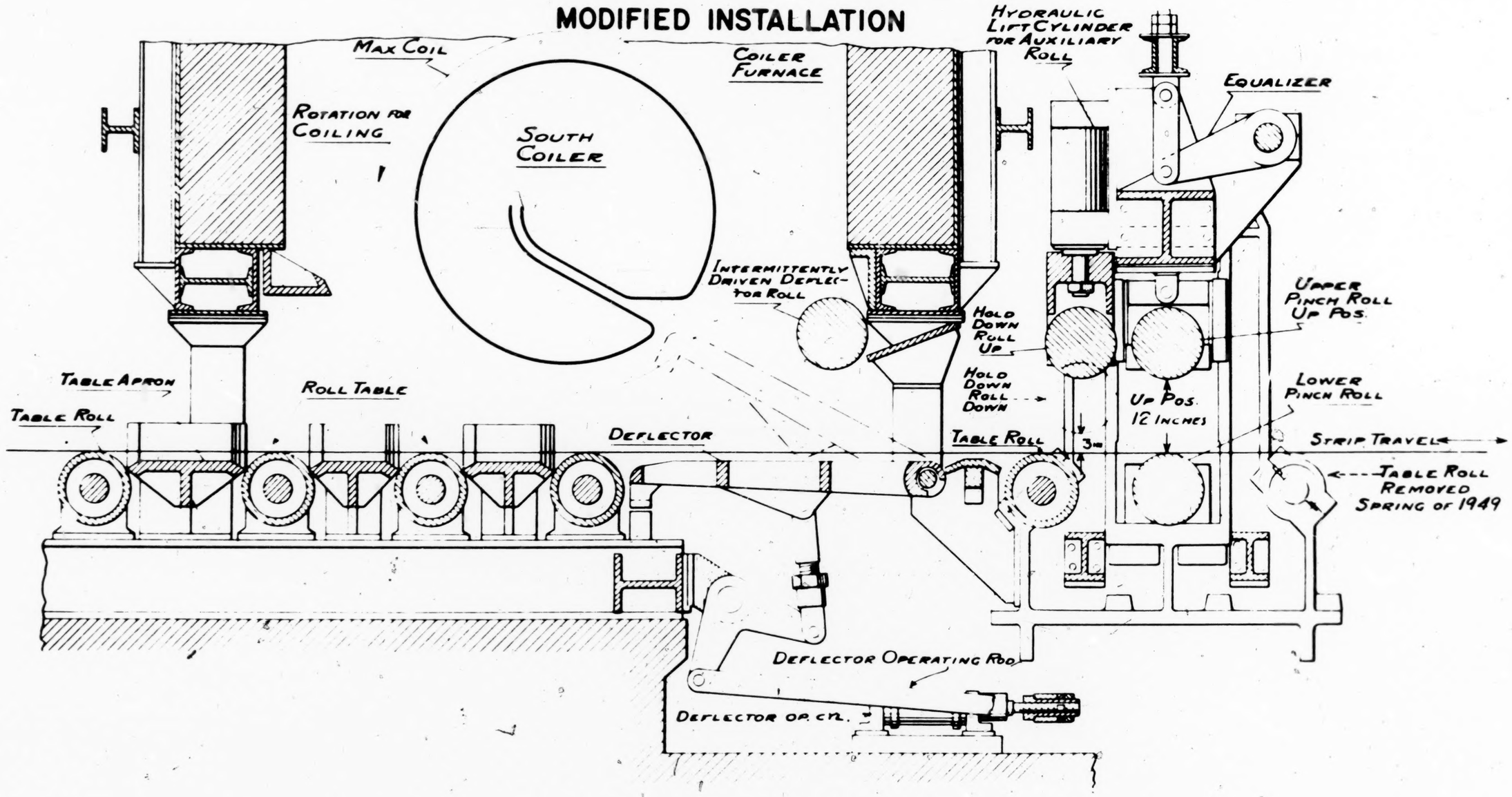
ORIGINAL INSTALLATION



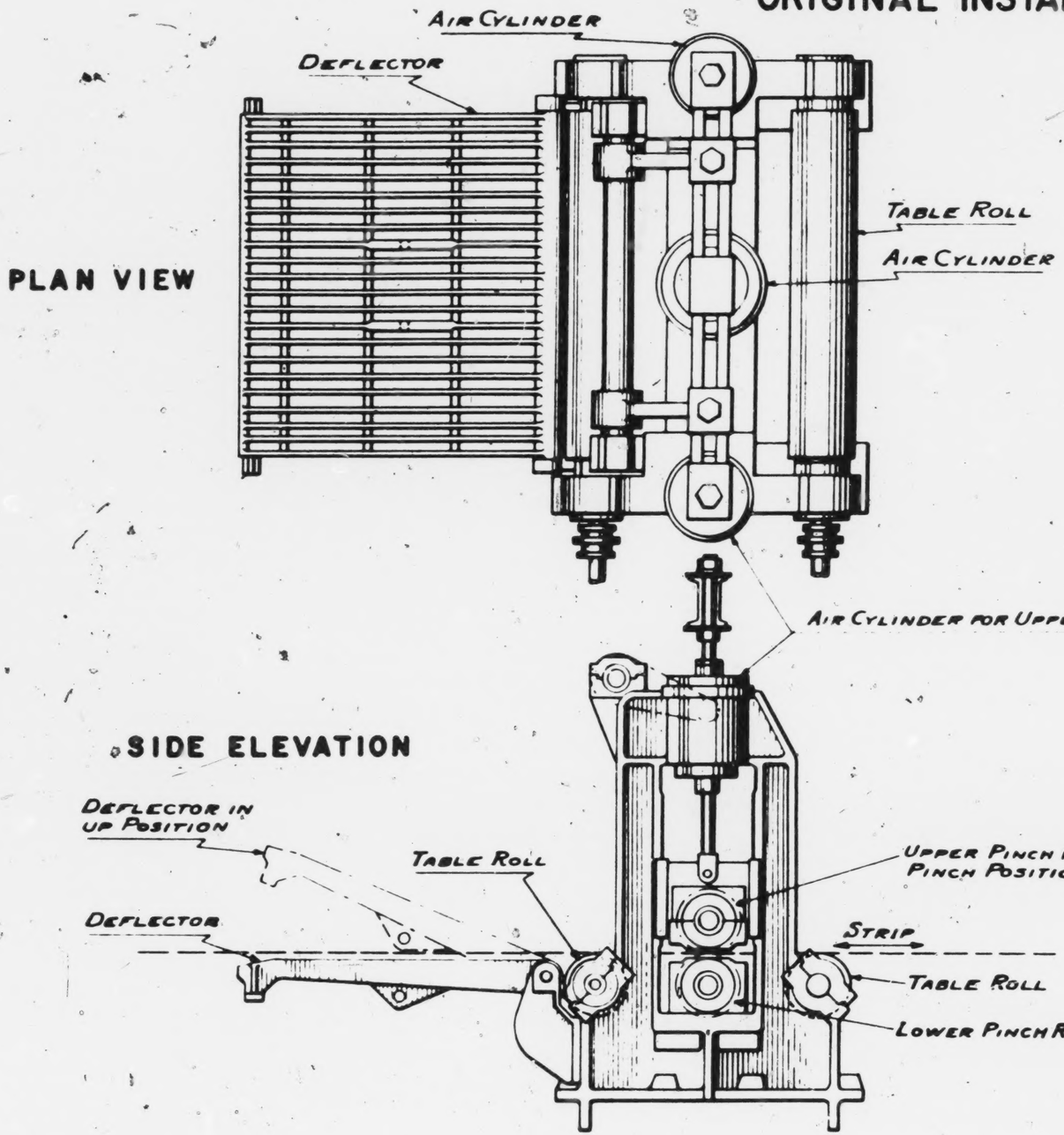
CRUCIBLE HOT STRIP MILL

VERTICAL SECTION AT PINCH ROLL & COILER

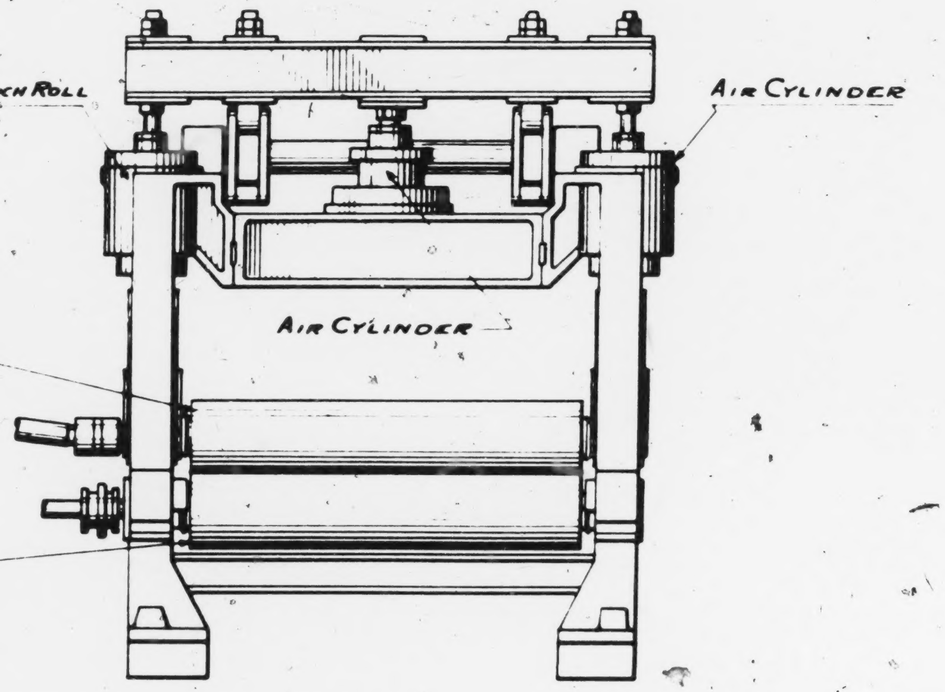
MODIFIED INSTALLATION



CRUCIBLE HOT STRIP MILL
ORIGINAL INSTALLATION



DEFLECTOR AND PINCH ROLL ASSEMBLY

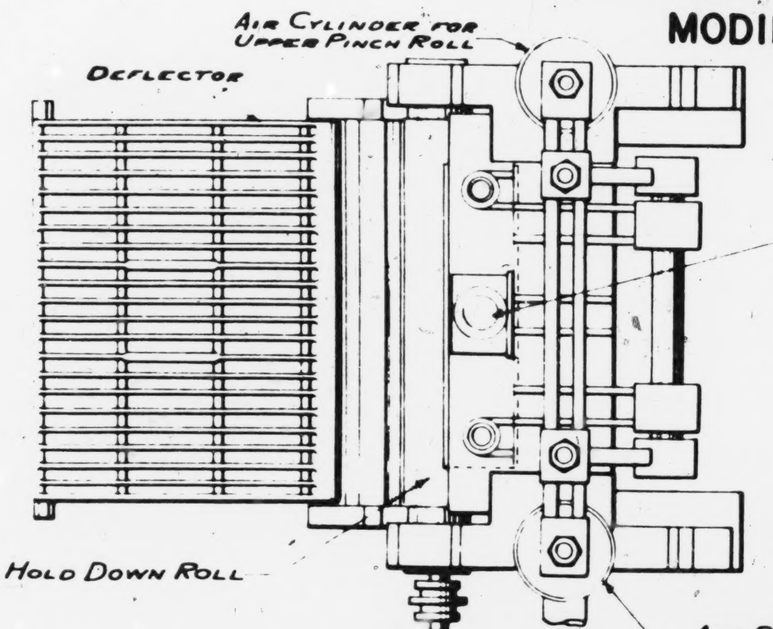


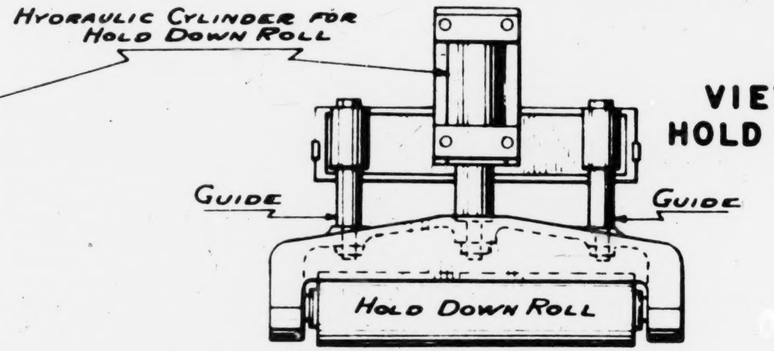
CRUCIBLE HOT STRIP MILL

MODIFIED INSTALLATION

DEFLECTOR AND PINCH ROLL ASSEMBLY

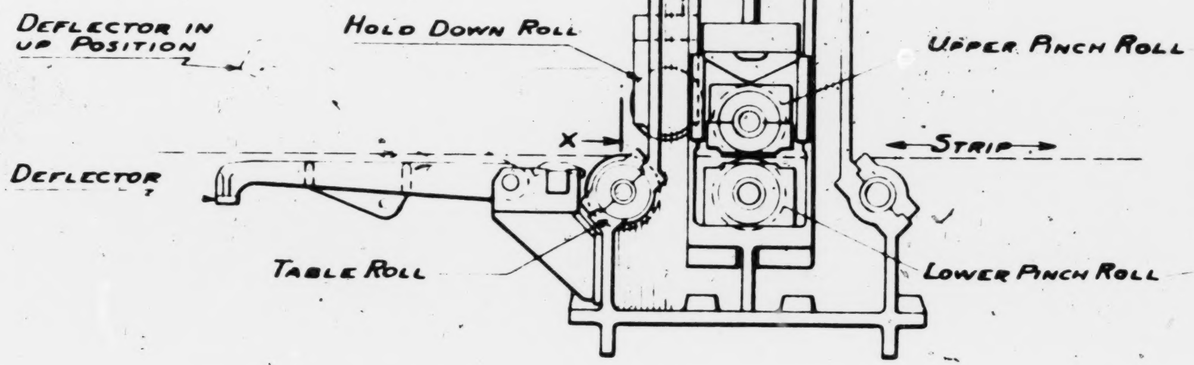
PLAN VIEW

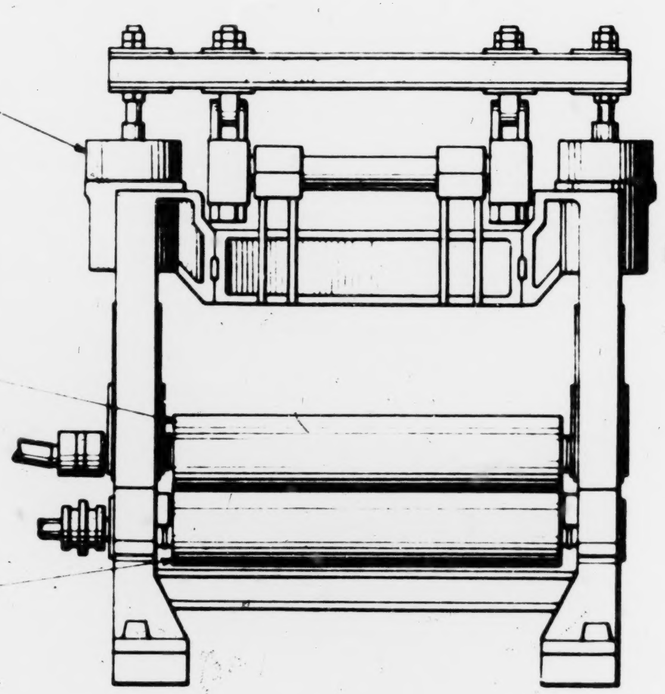




VIEW X-X
HOLD DOWN ROLL

SIDE ELEVATION



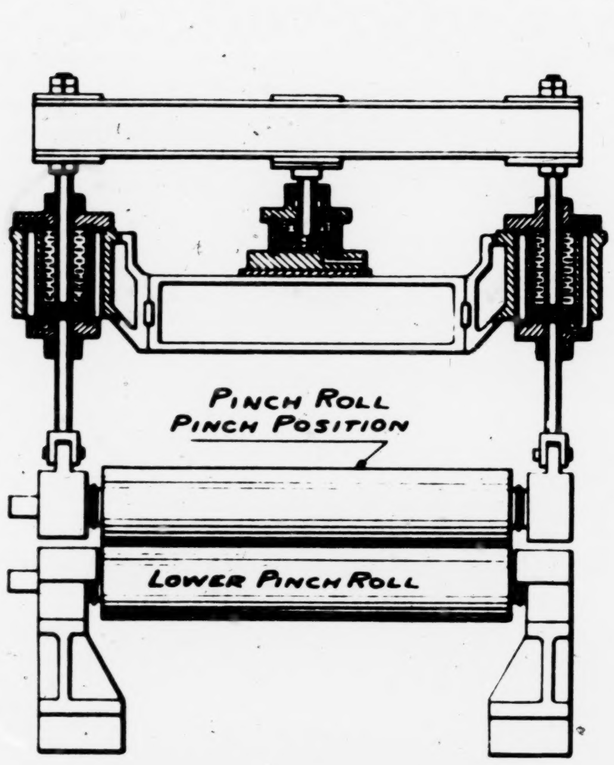


FRONT ELEV.

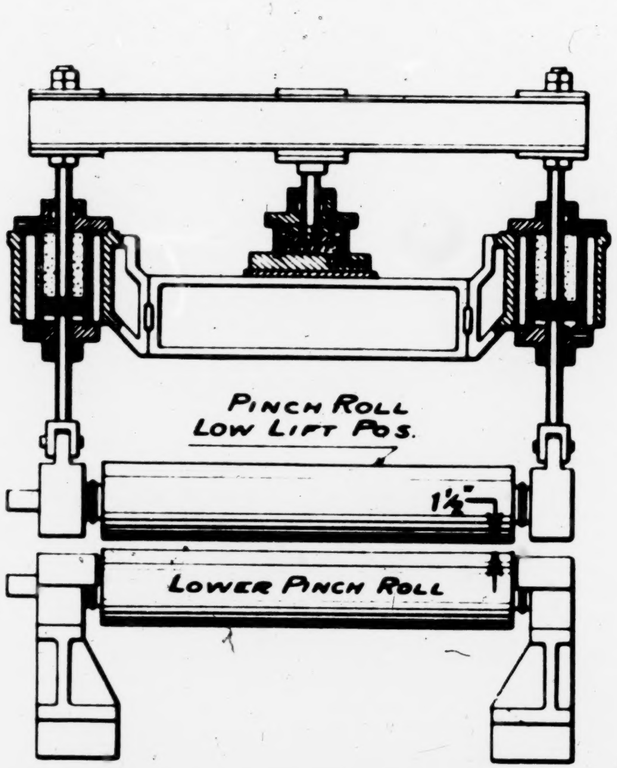
CRUCIBLE HOT STRIP MILL

PINCH ROLL OPERATION

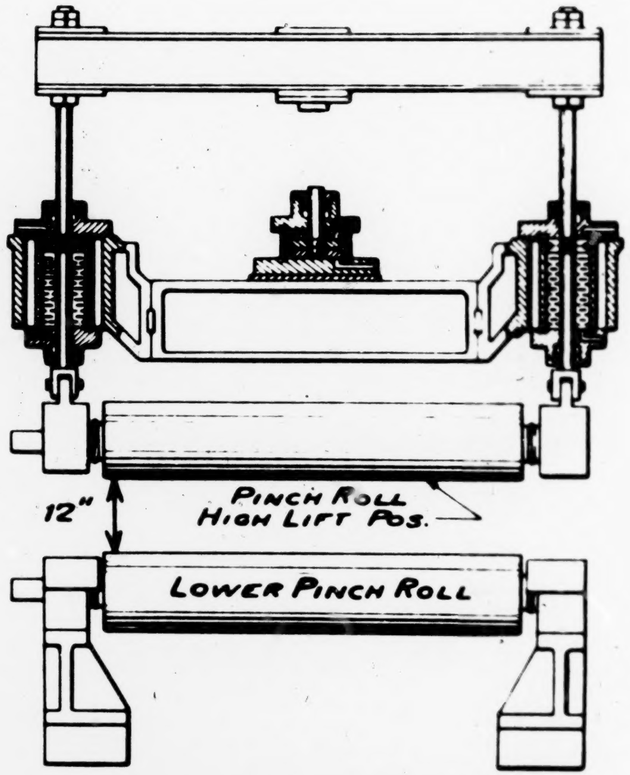
ORIGINAL INSTALLATION



PINCH POSITION



LOW LIFT POSITION



HIGH LIFT POSITION

LEGEND

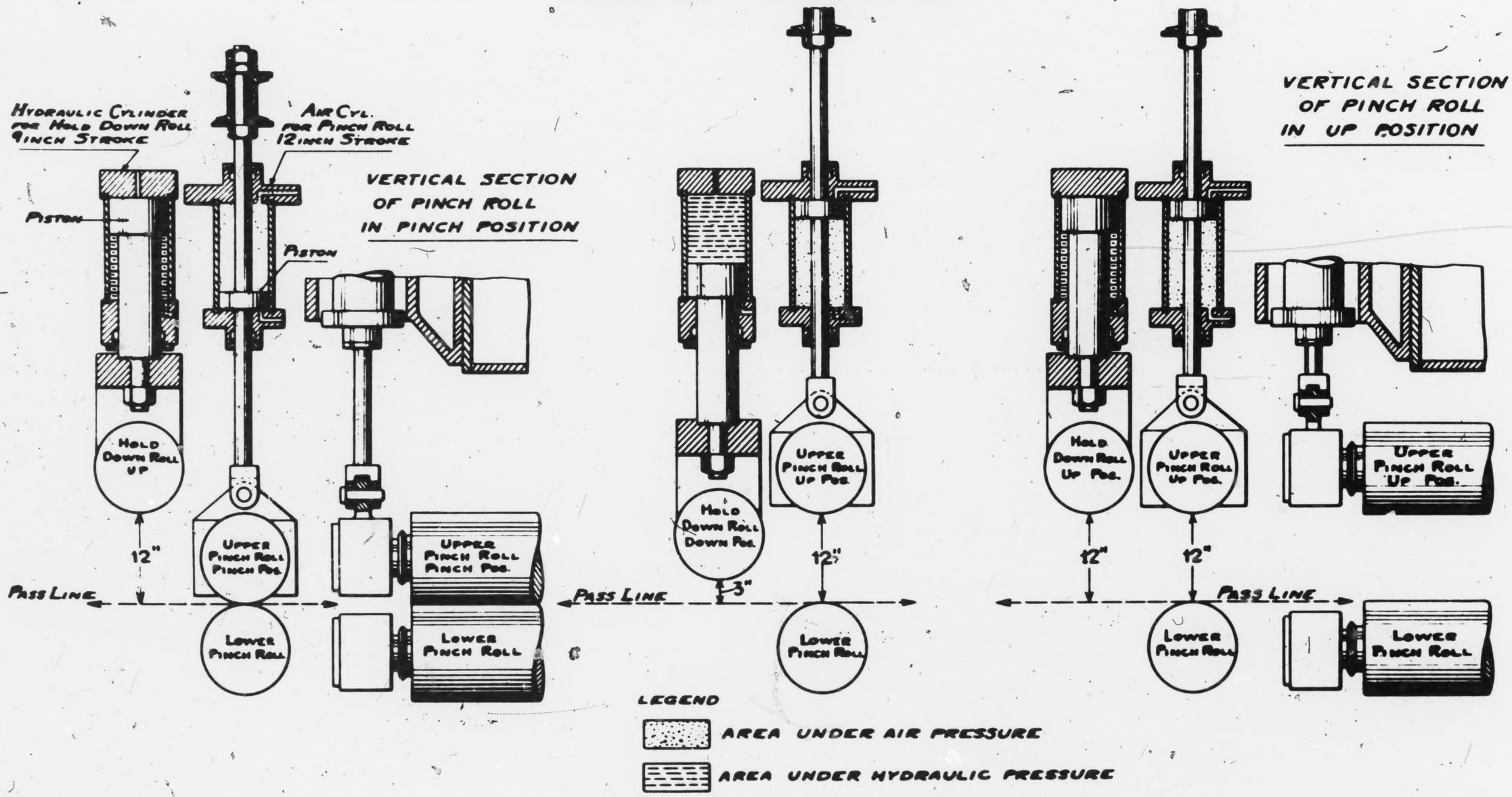
AREA UNDER CONSTANT AIR PRESSURE

AREA AIR LOCKED (CUSHIONED)

CRUCIBLE HOT STRIP MILL

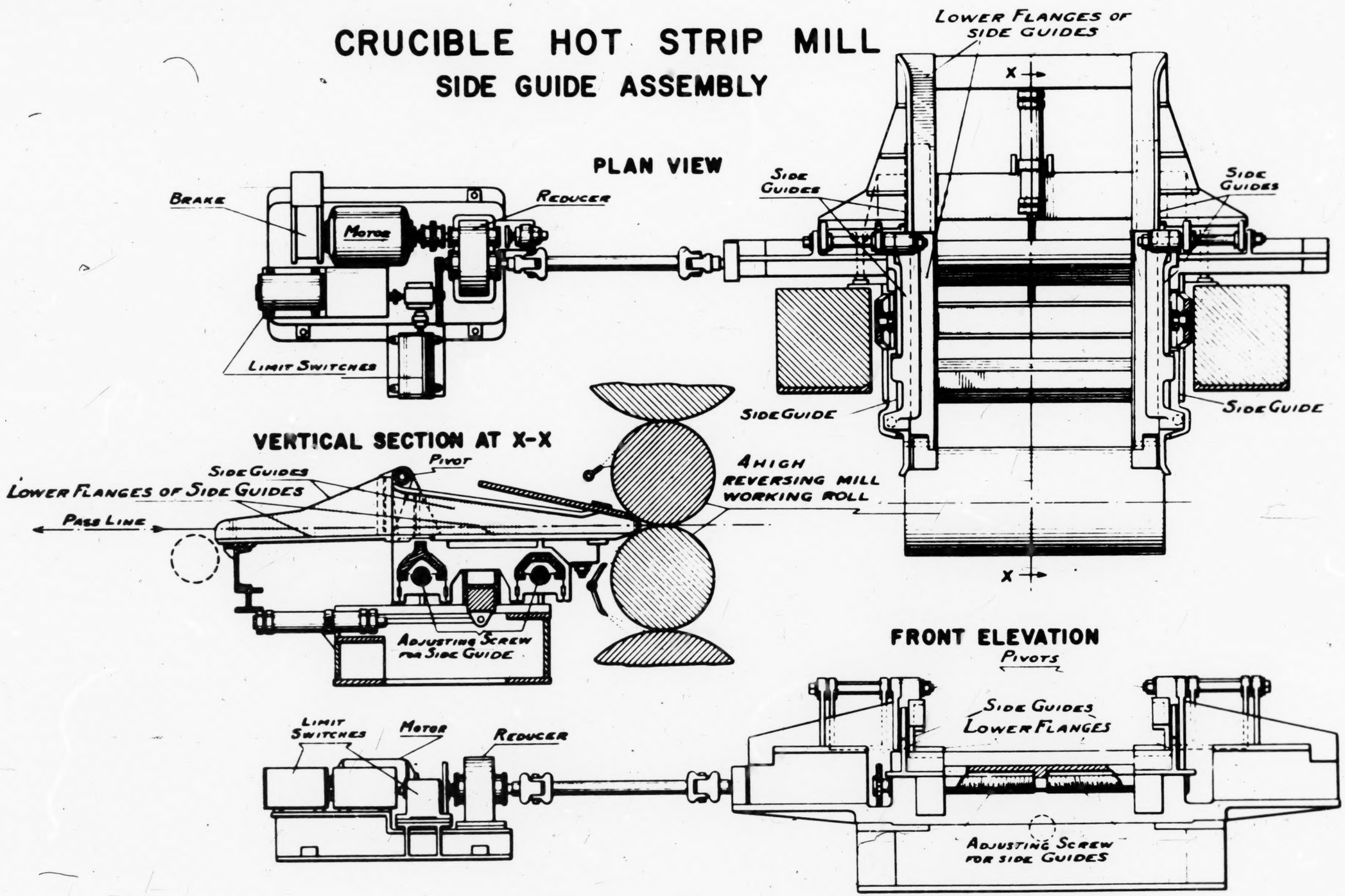
PINCH ROLL & AUXILIARY ROLL ARRANGEMENT

MODIFIED INSTALLATION



CRUCIBLE HOT STRIP MILL

SIDE GUIDE ASSEMBLY



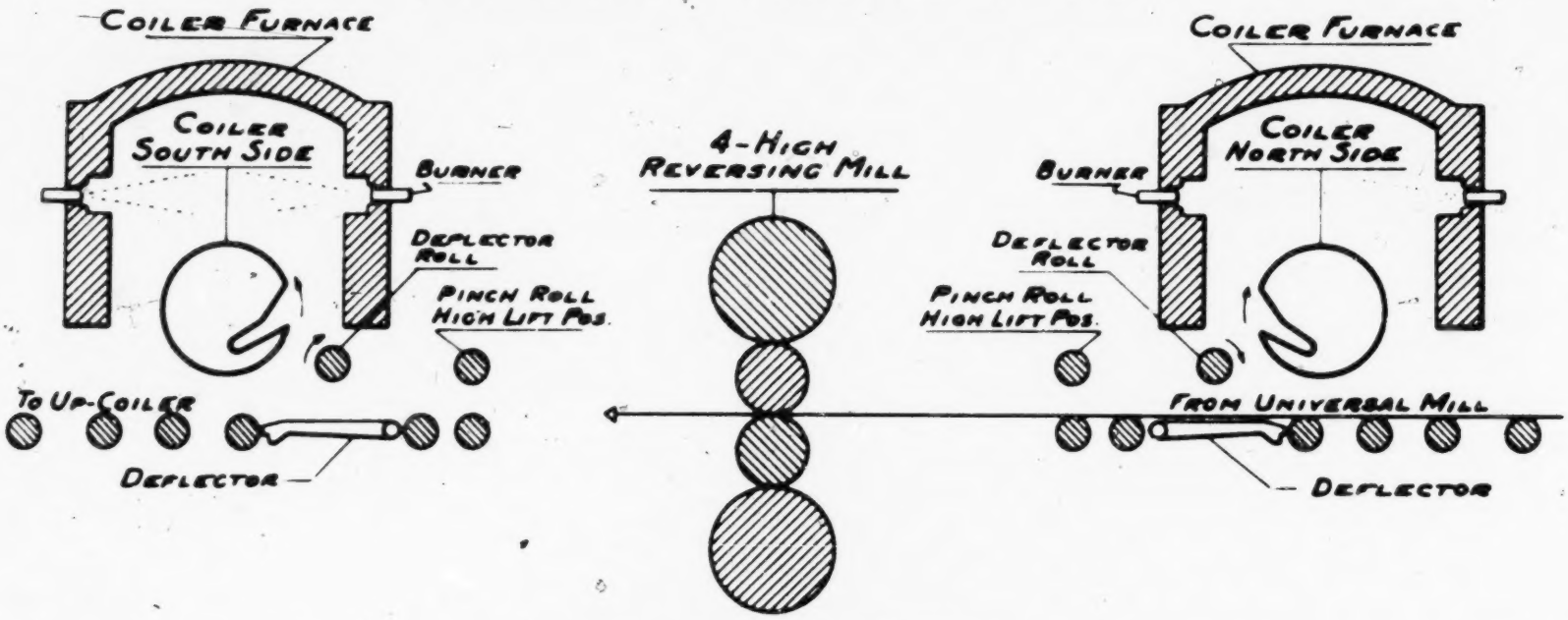
A 11

CRUCIBLE HOT STRIP MILL

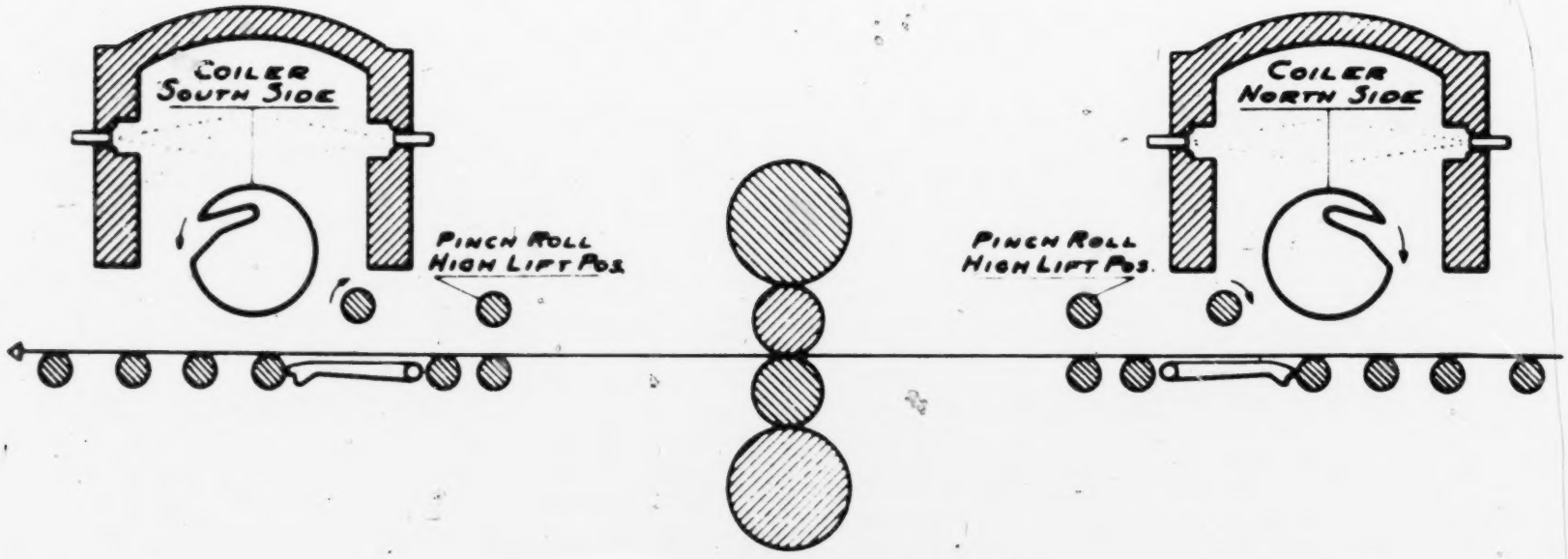
OPERATIONAL DRAWING NO. 1

NORTH →

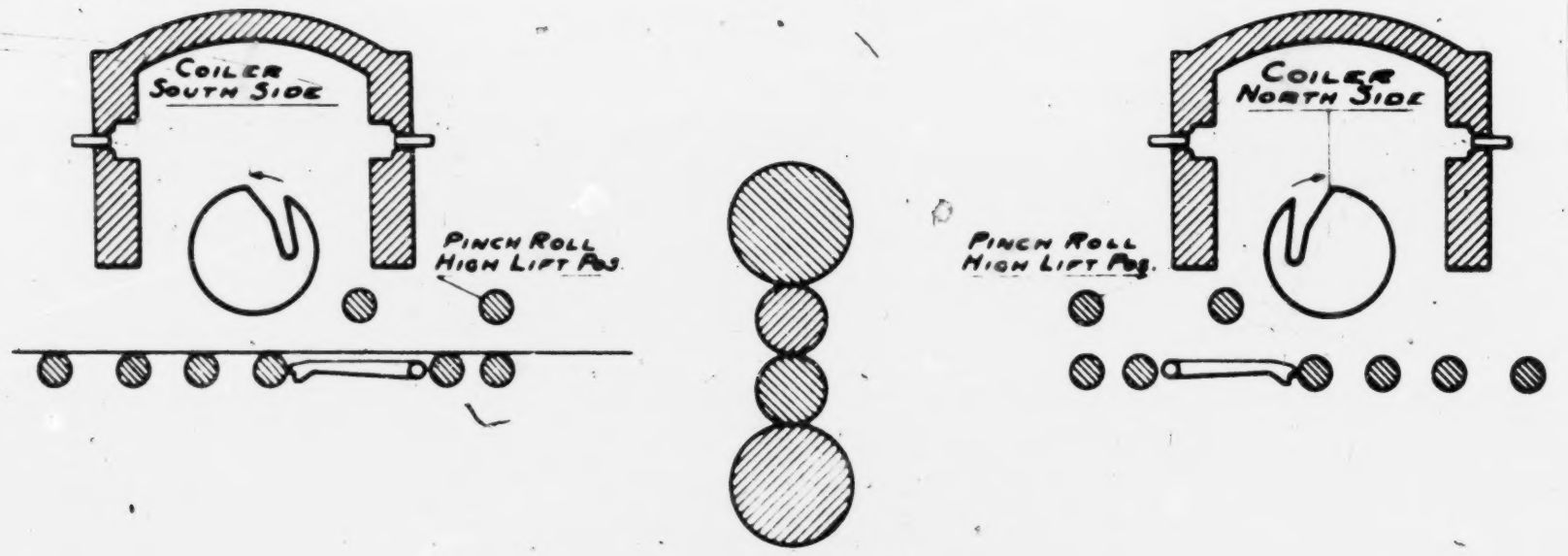
ORIGINAL INSTALLATION



FIRST PASS STARTED



FIRST PASS ROLLING



FIRST PASS COMPLETED

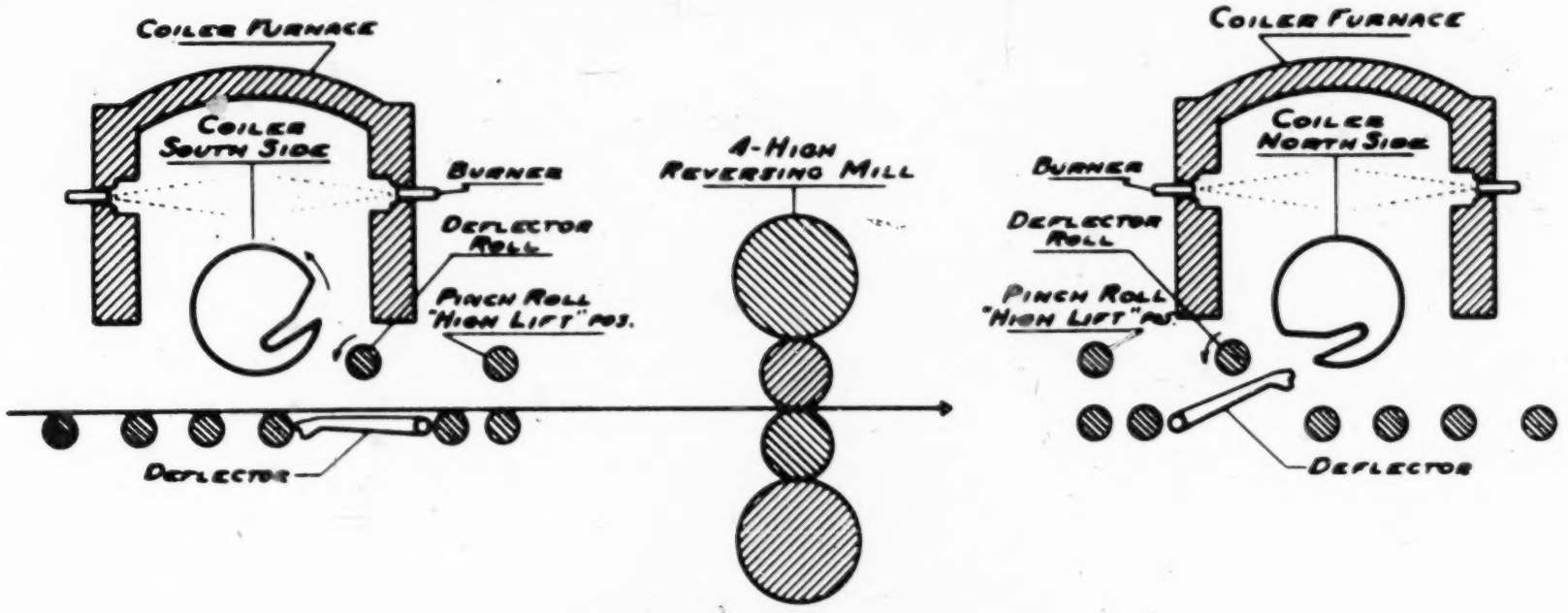
A 12

CRUCIBLE HOT STRIP MILL

OPERATIONAL DRAWING NO. 2

NORTH →

ORIGINAL INSTALLATION



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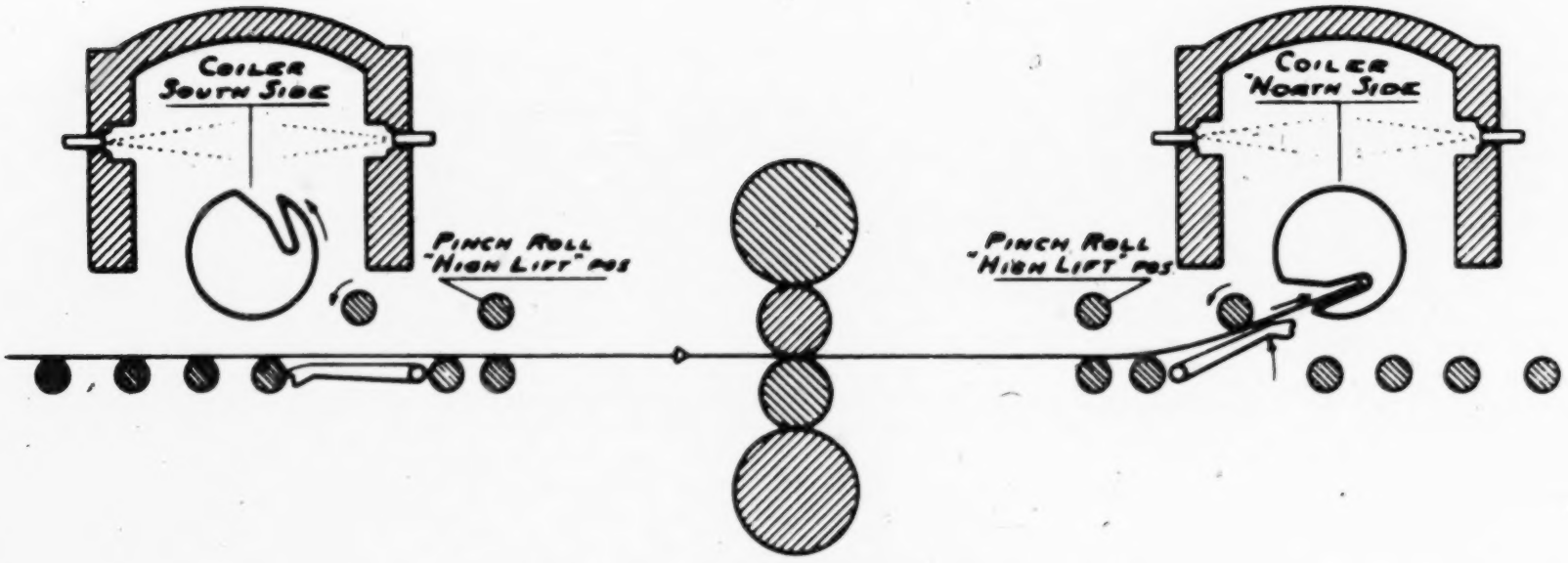
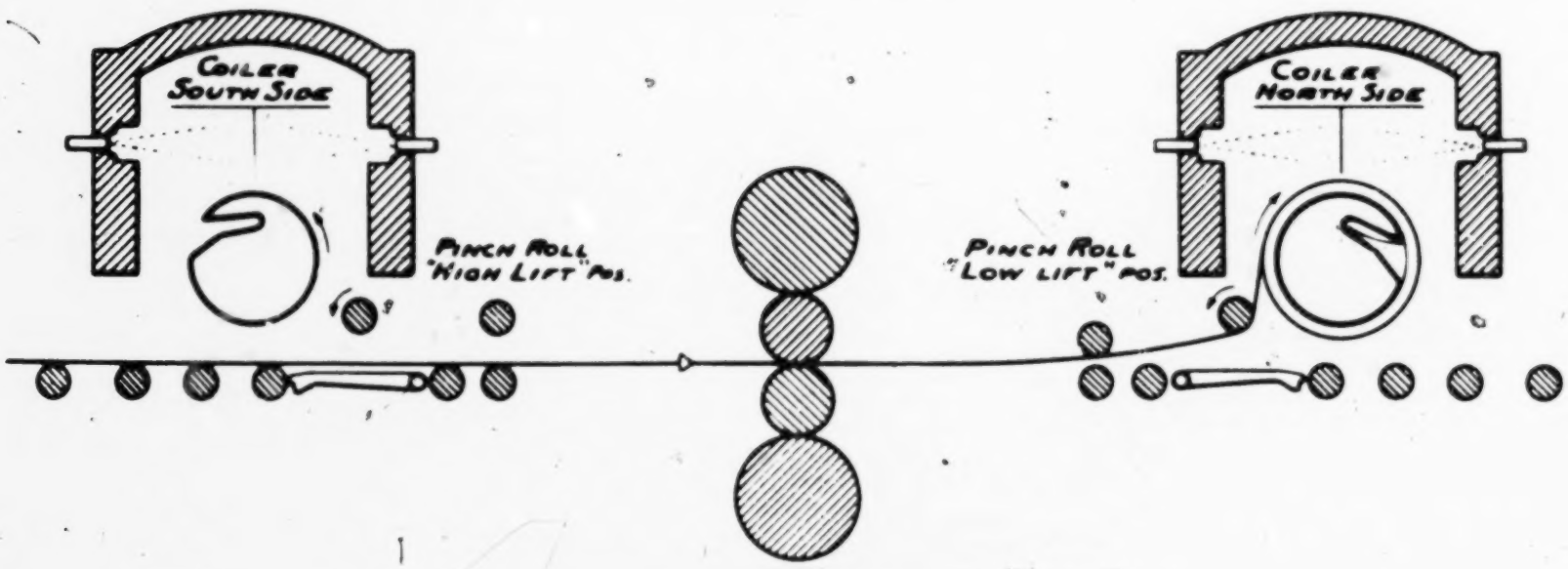


SECOND PASS – STRIP ENTERING COILER ON NORTH SIDE



SECOND PASS DURING ROLLING.

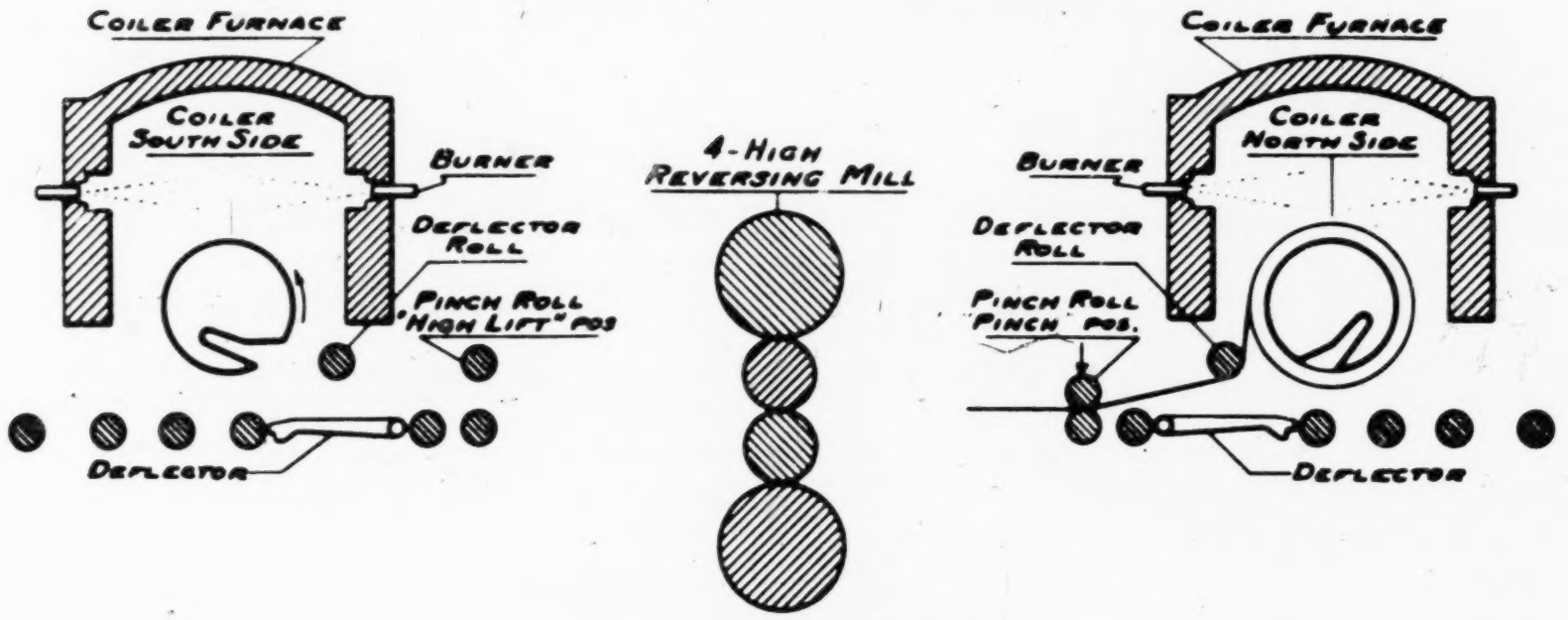
A 13

CRUCIBLE HOT STRIP MILL

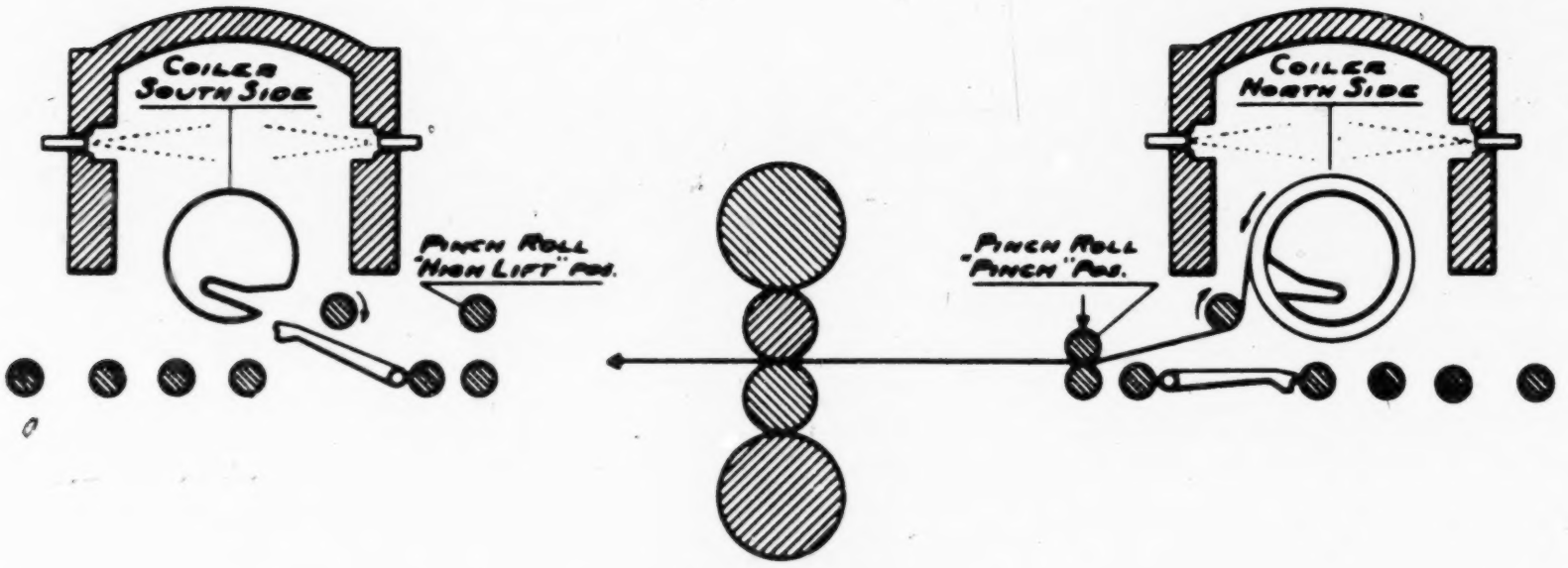
OPERATIONAL DRAWING NO. 3

NORTH →

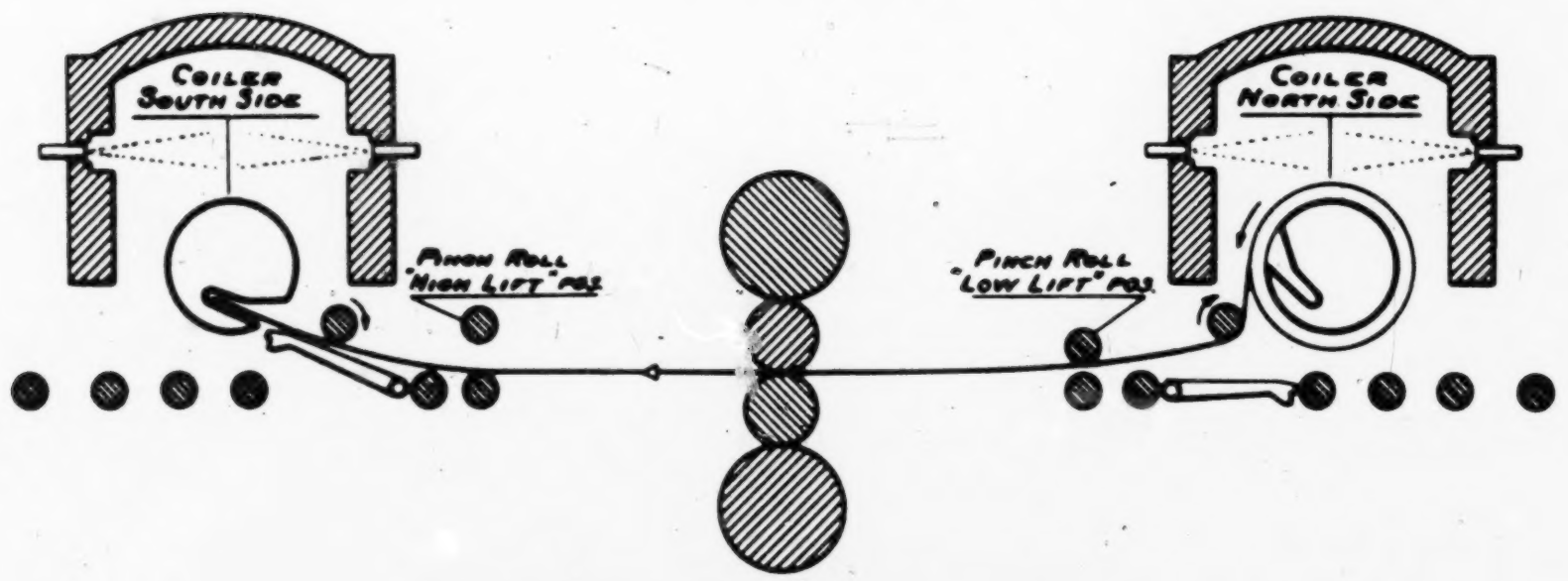
ORIGINAL INSTALLATION



SECOND PASS COMPLETED



THIRD PASS STARTED



THIRD PASS ENTERING SOUTH COILER

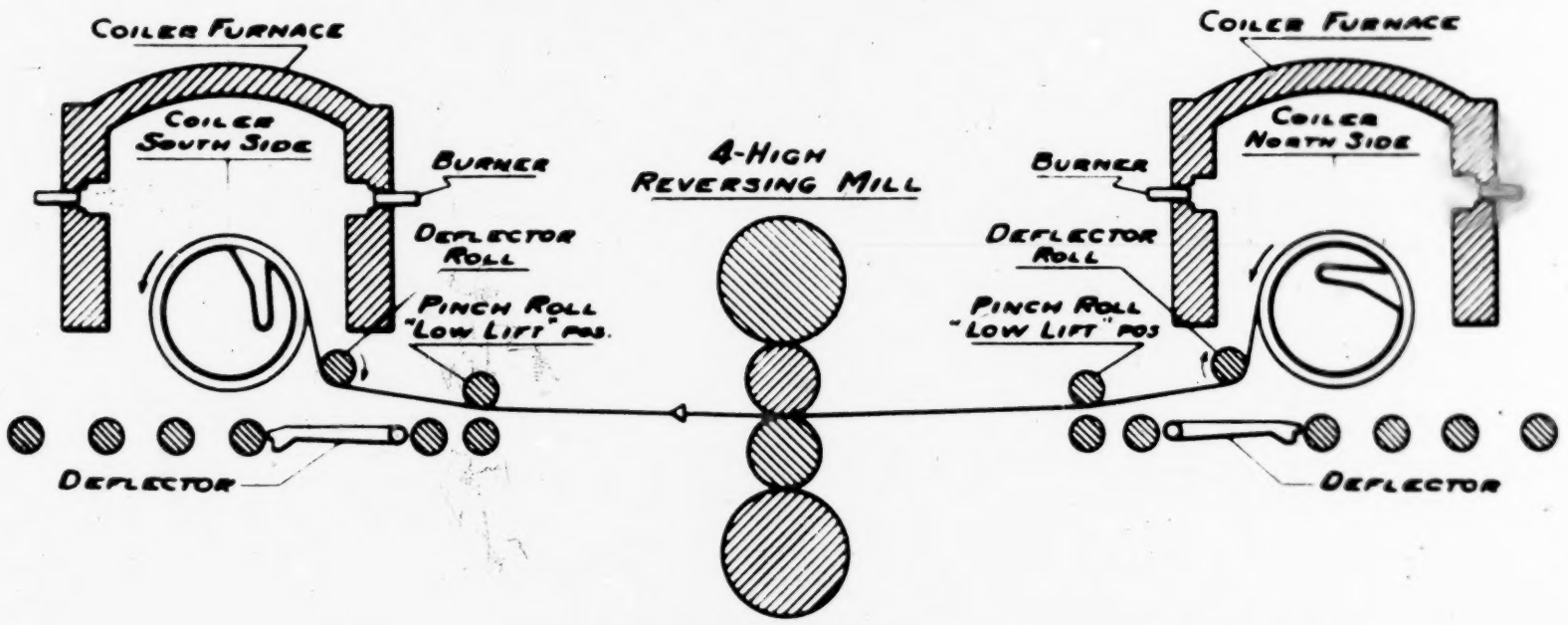
A 14

CRUCIBLE HOT STRIP MILL

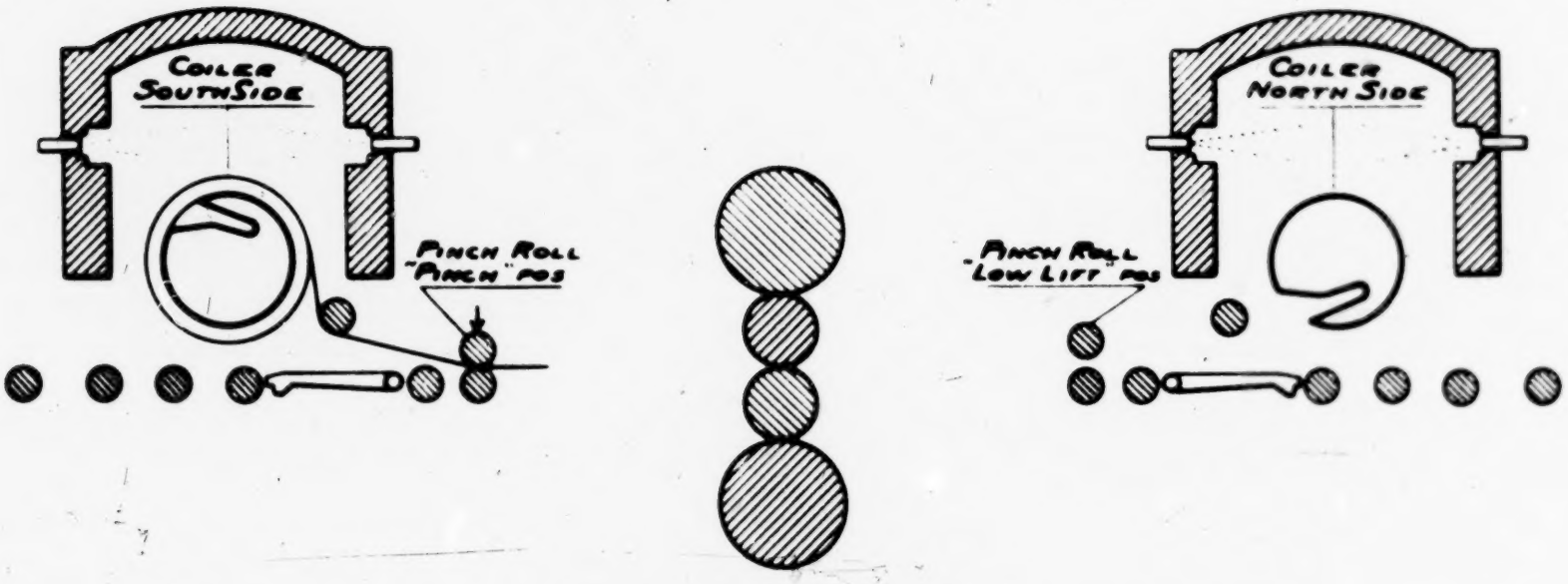
OPERATIONAL DRAWING NO. 4

NORTH →

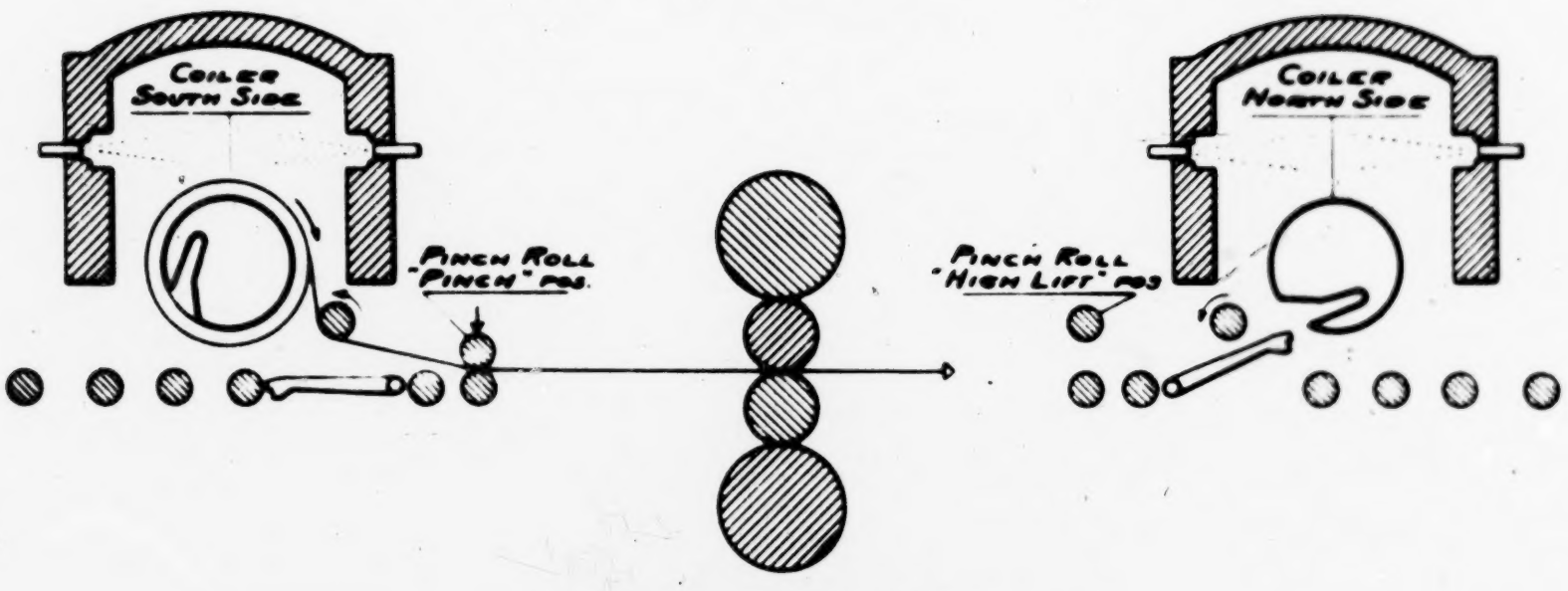
ORIGINAL INSTALLATION



THIRD PASS ROLLING



THIRD PASS COMPLETED



FOURTH PASS STARTED

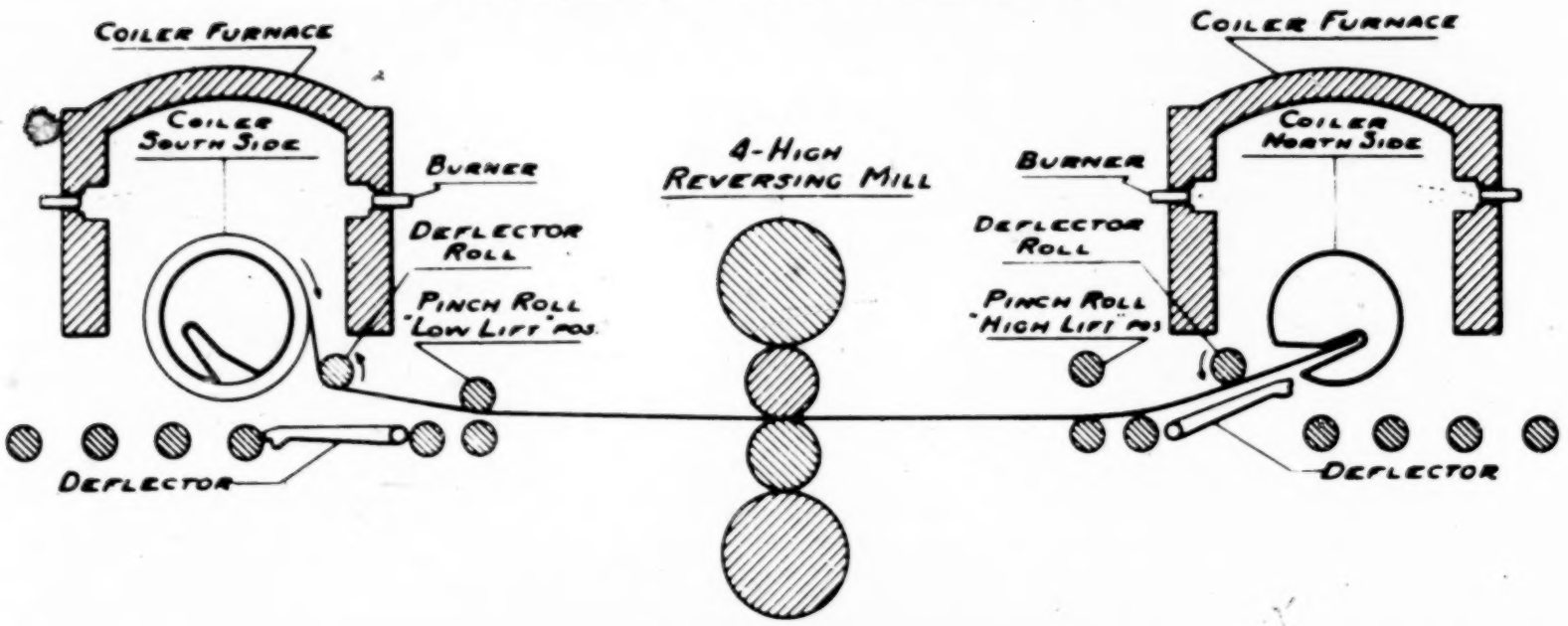
A15

CRUCIBLE HOT STRIP MILL

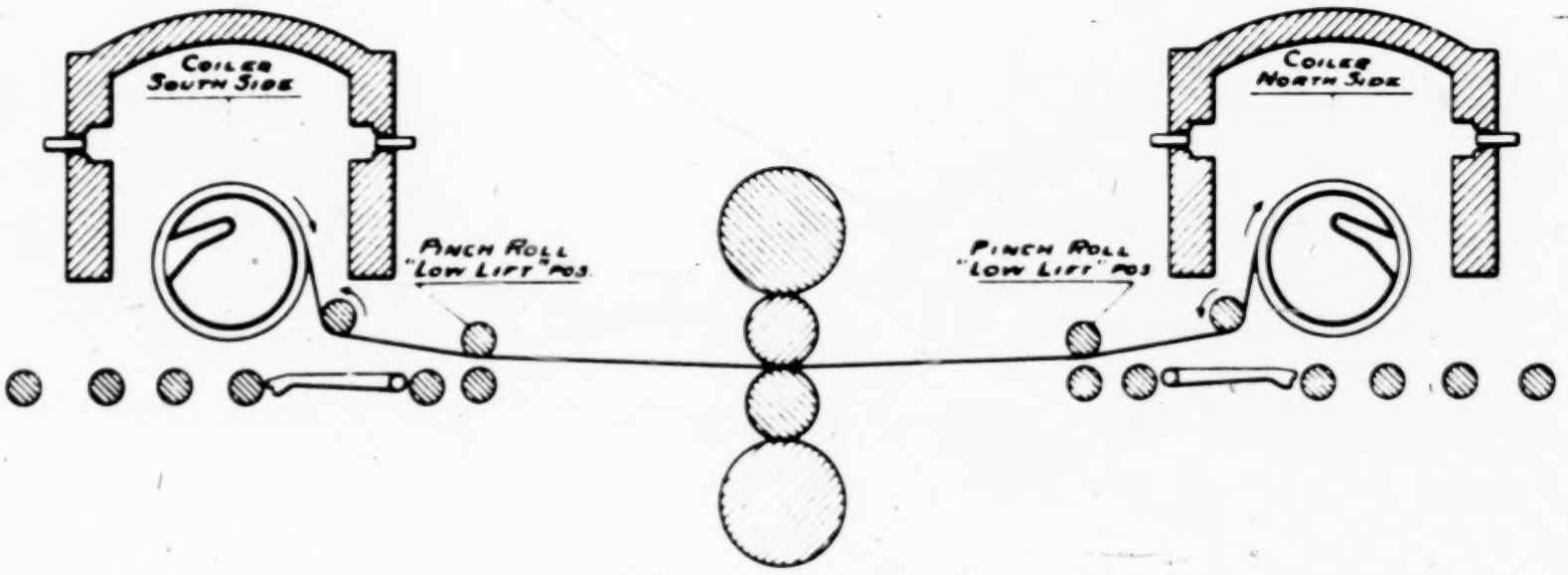
OPERATIONAL DRAWING NO. 5

NORTH →

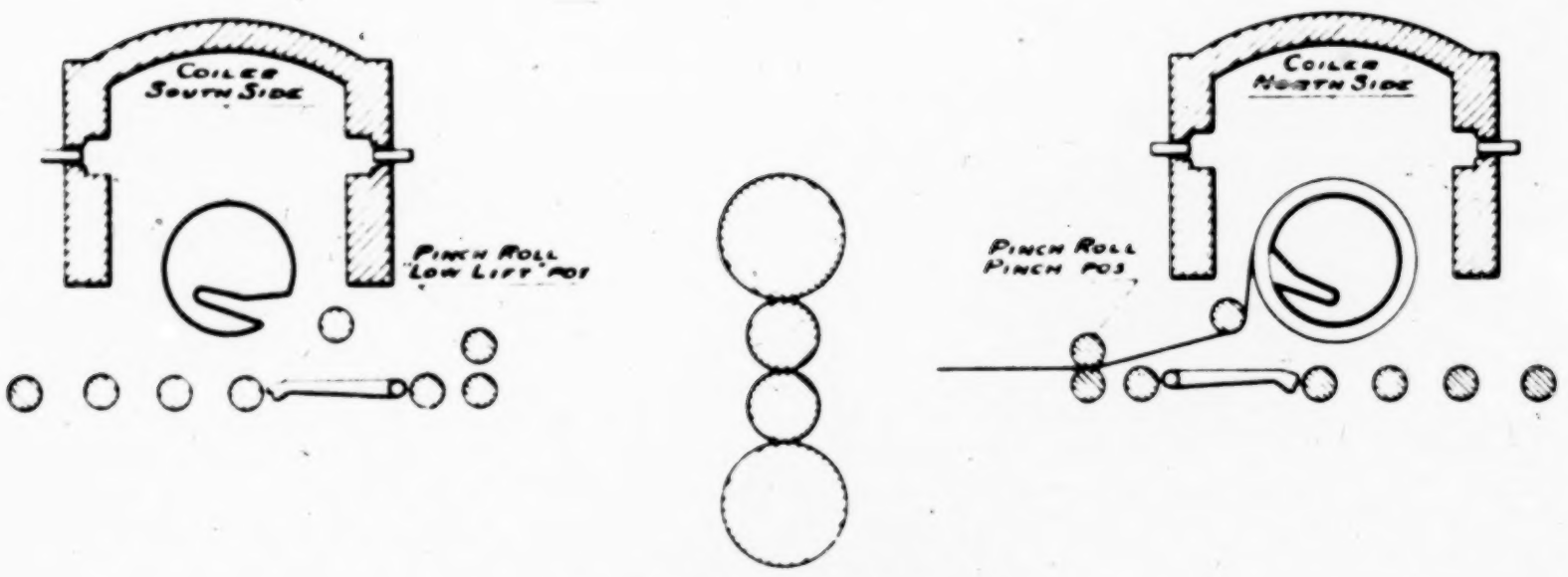
ORIGINAL INSTALLATION



FOURTH PASS ENTERING NORTH COILER



FOURTH PASS ROLLING



FOURTH PASS COMPLETED

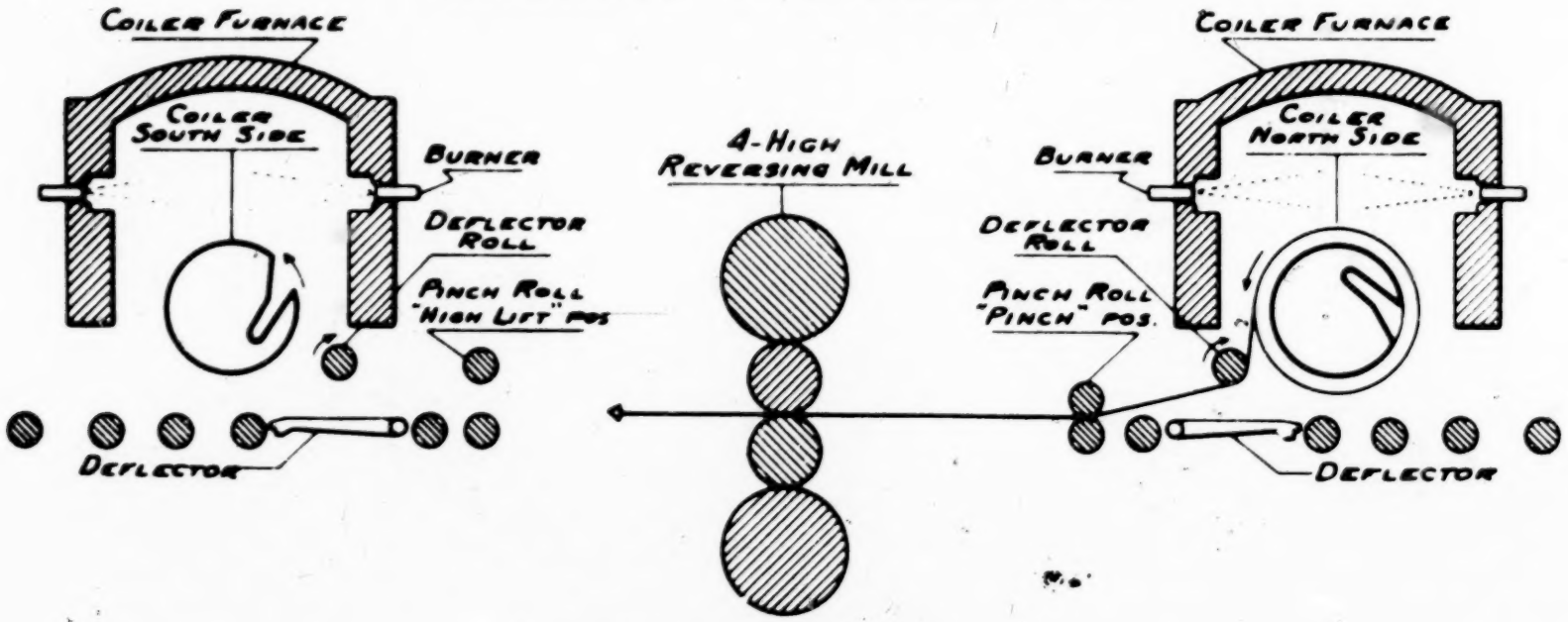
A16

CRUCIBLE HOT STRIP MILL

OPERATIONAL DRAWING NO: 6

NORTH →

ORIGINAL INSTALLATION



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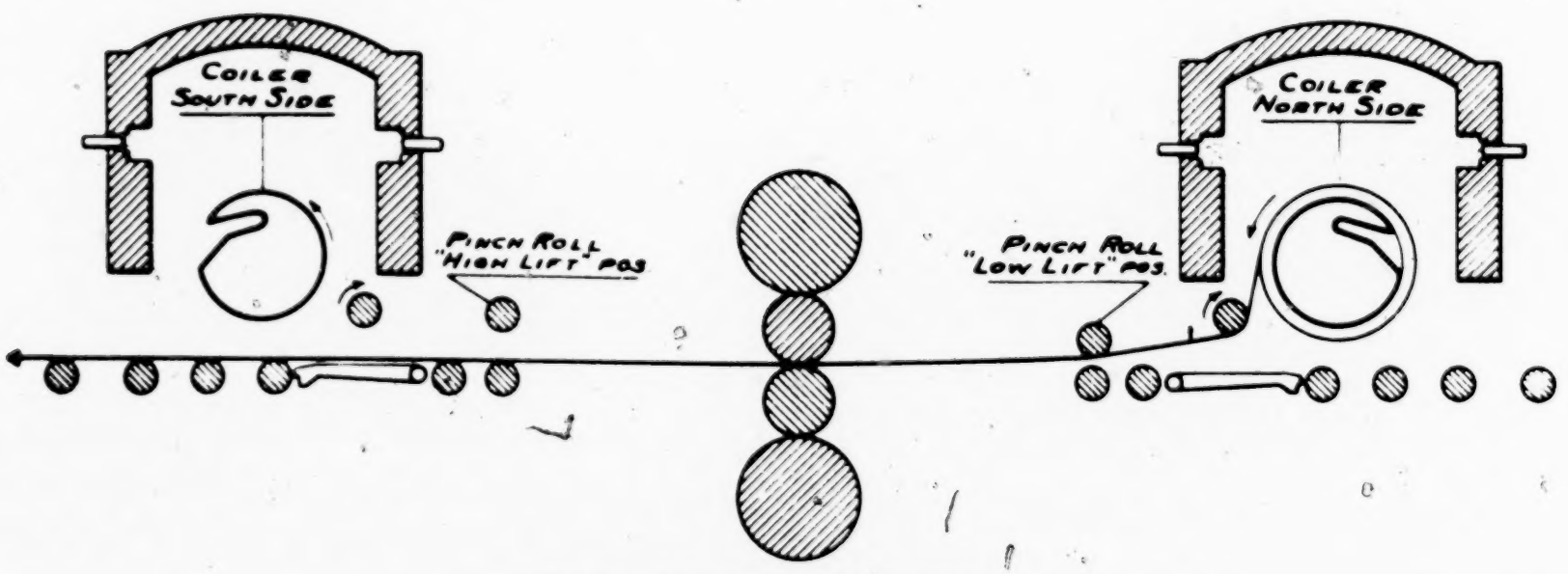


FINAL PASS DURING ROLLING

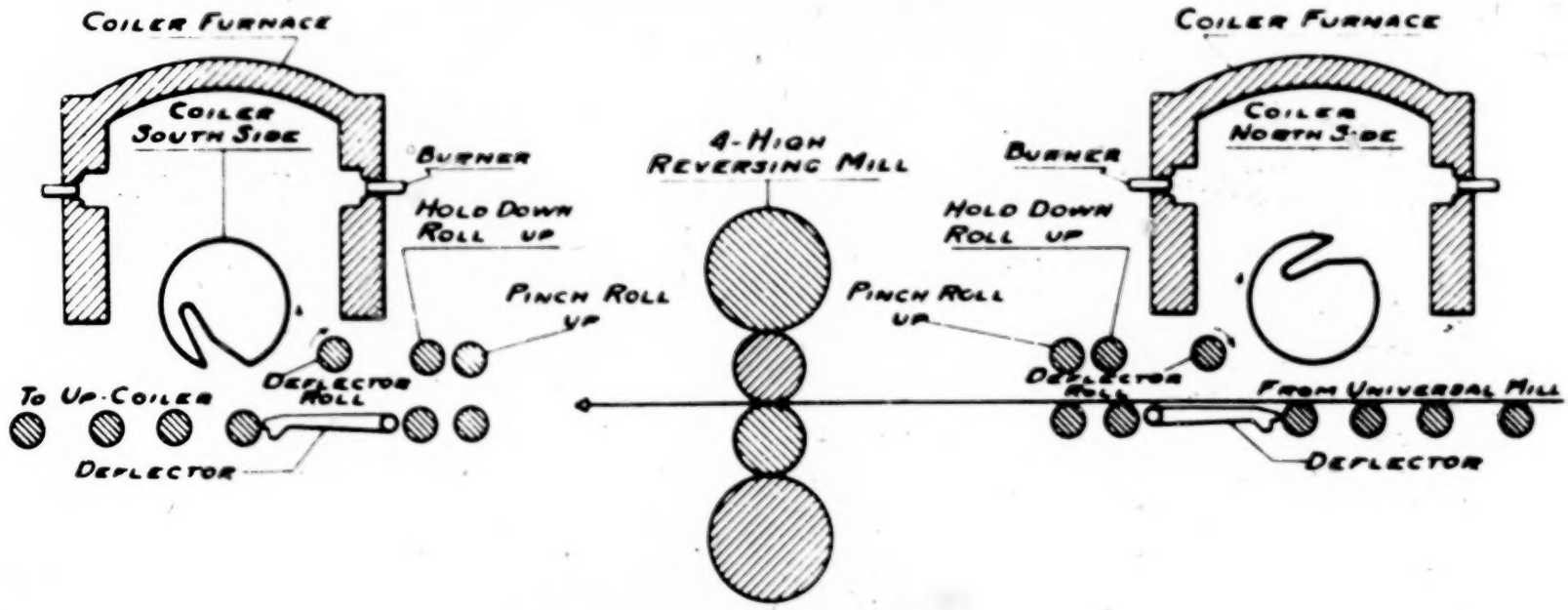
A17

CRUCIBLE HOT STRIP MILL

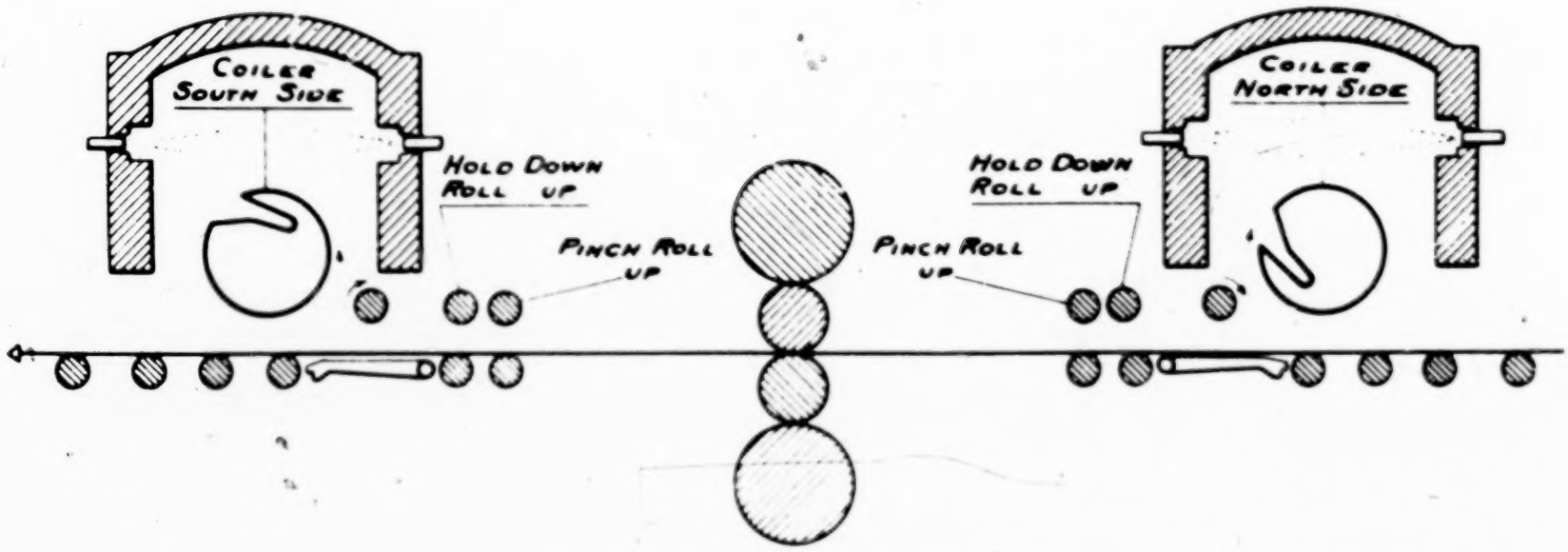
OPERATIONAL DRAWING NO. 7

NORTH →

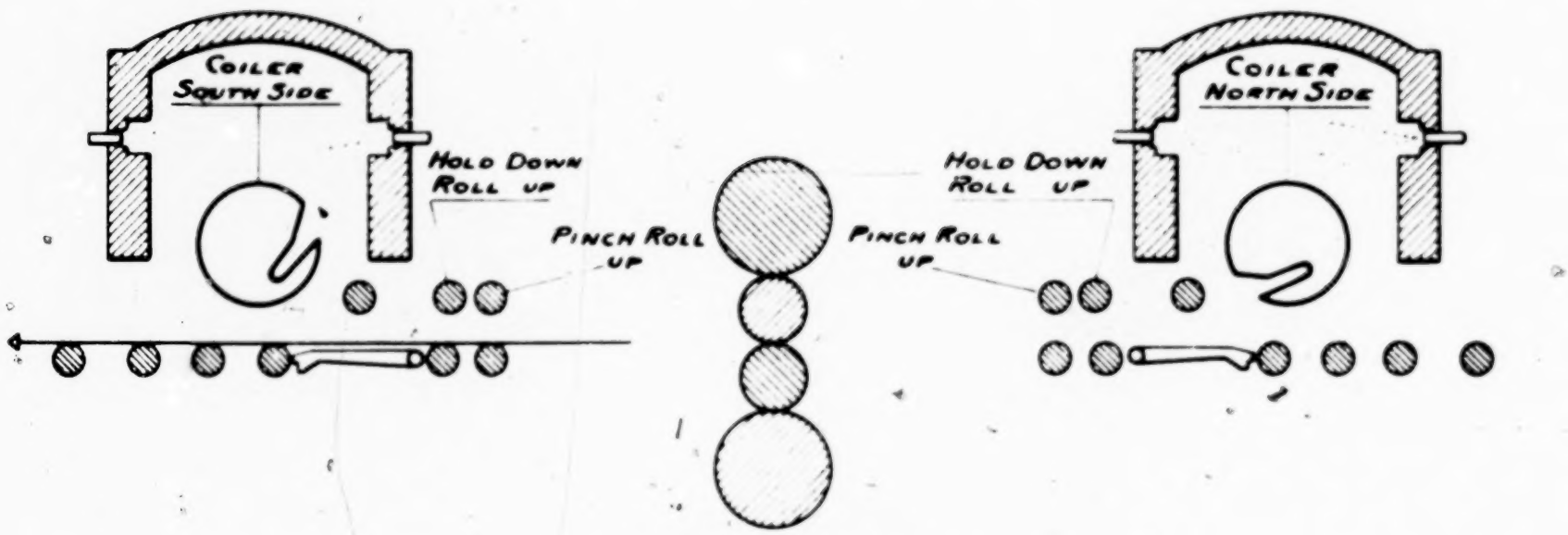
MODIFIED INSTALLATION



FIRST PASS STARTED



FIRST PASS ROLLING



FIRST PASS COMPLETED

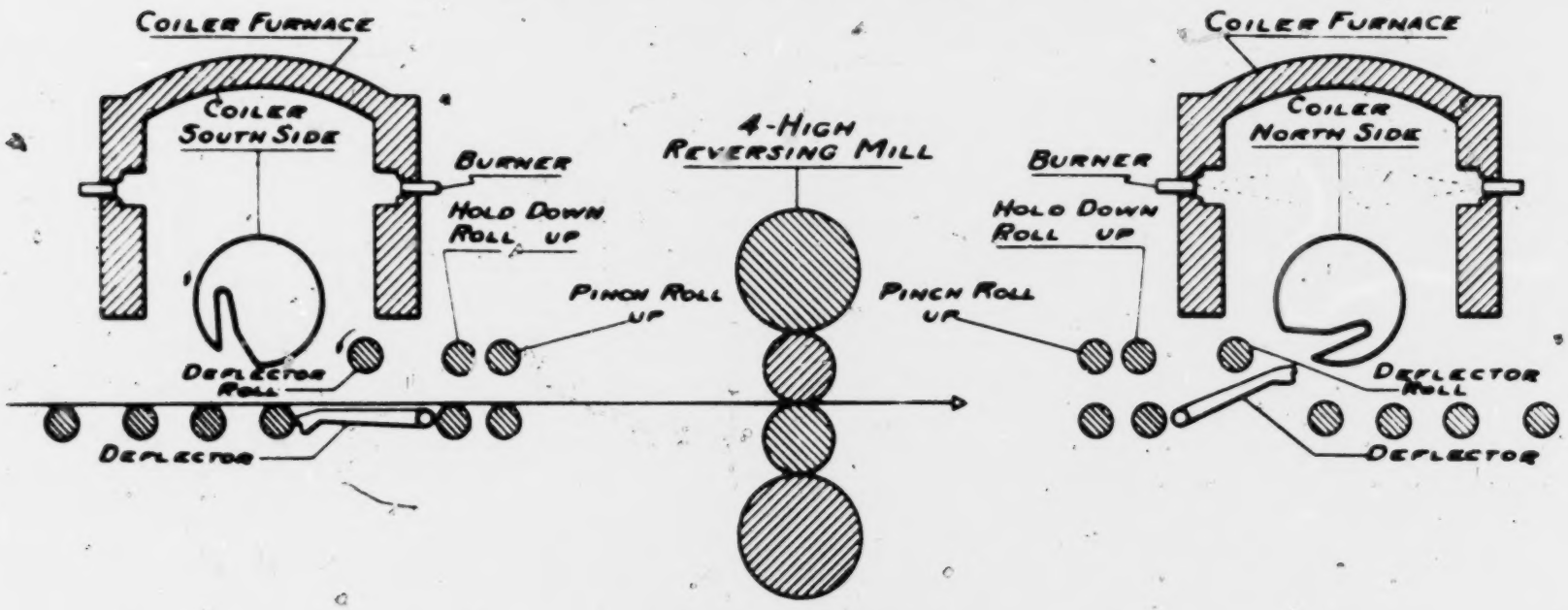
A18

CRUCIBLE HOT STRIP MILL

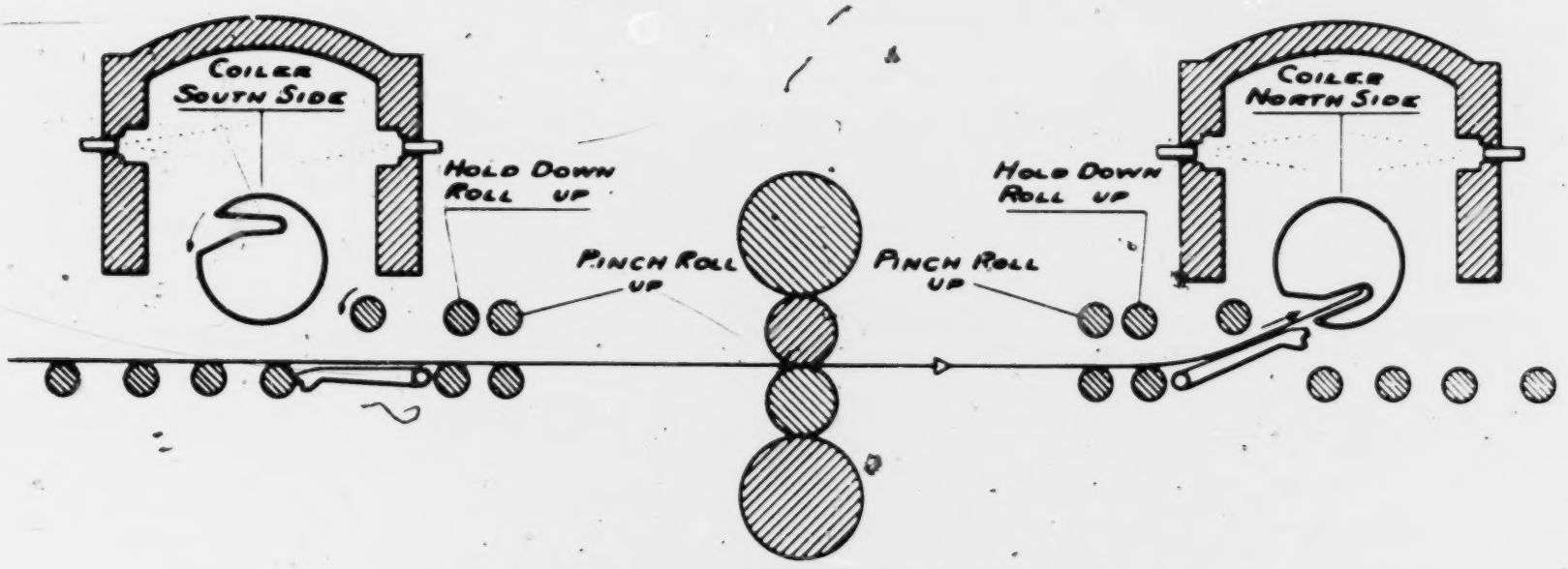
OPERATIONAL DRAWING, NO. 8

NORTH →

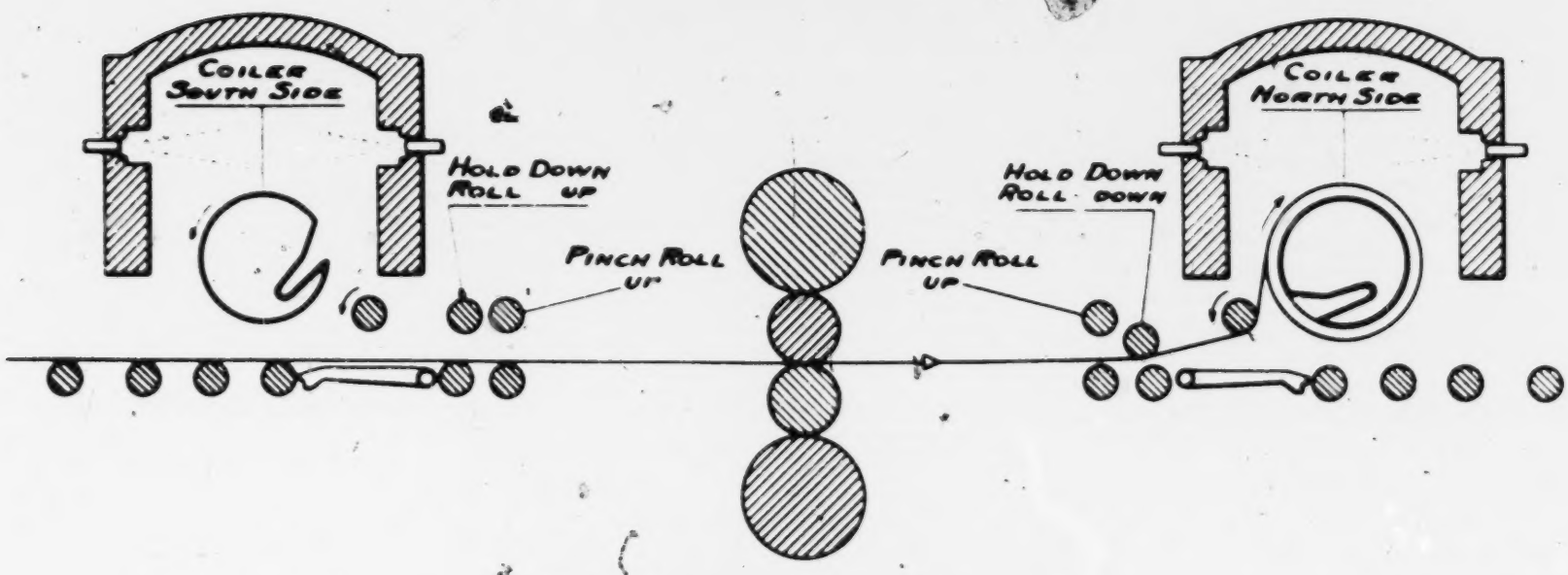
MODIFIED INSTALLATION



SECOND PASS STARTED



SECOND PASS - STRIP ENTERING COILER ON NORTH SIDE



SECOND PASS DURING ROLLING

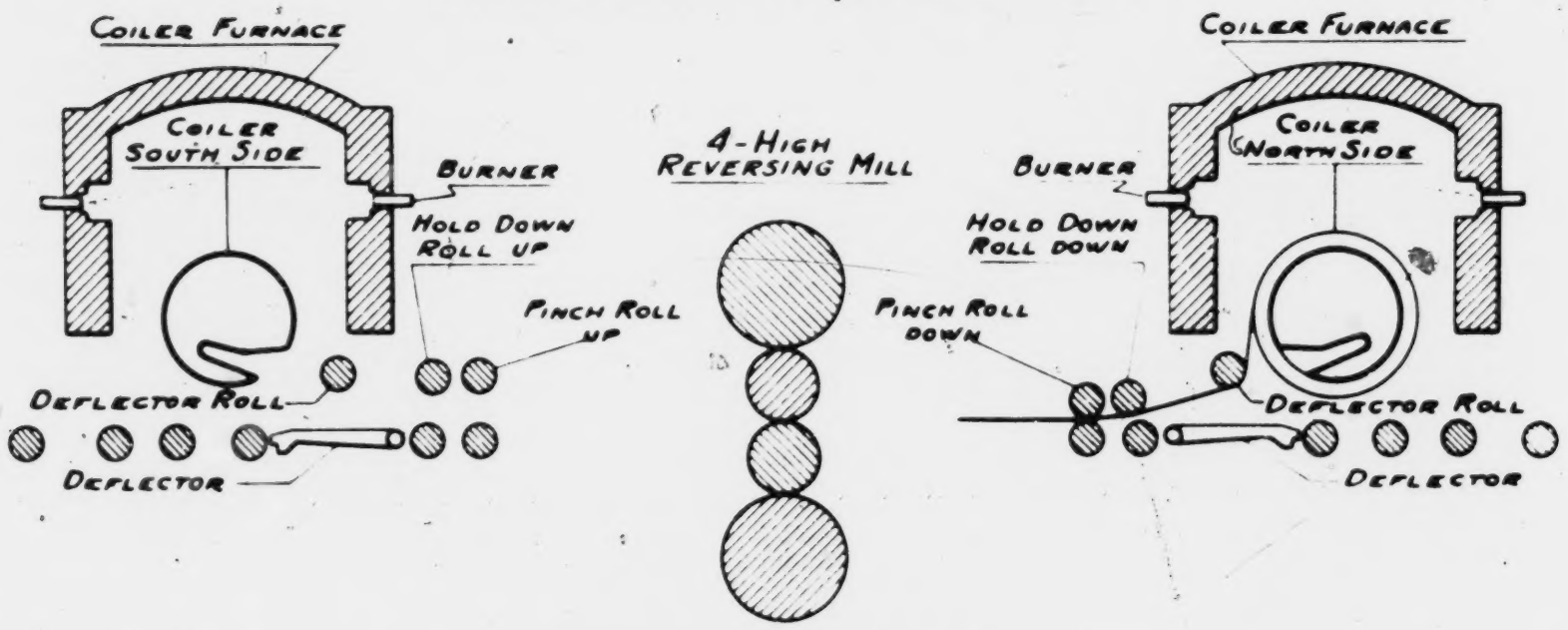
A19

CRUCIBLE HOT STRIP MILL

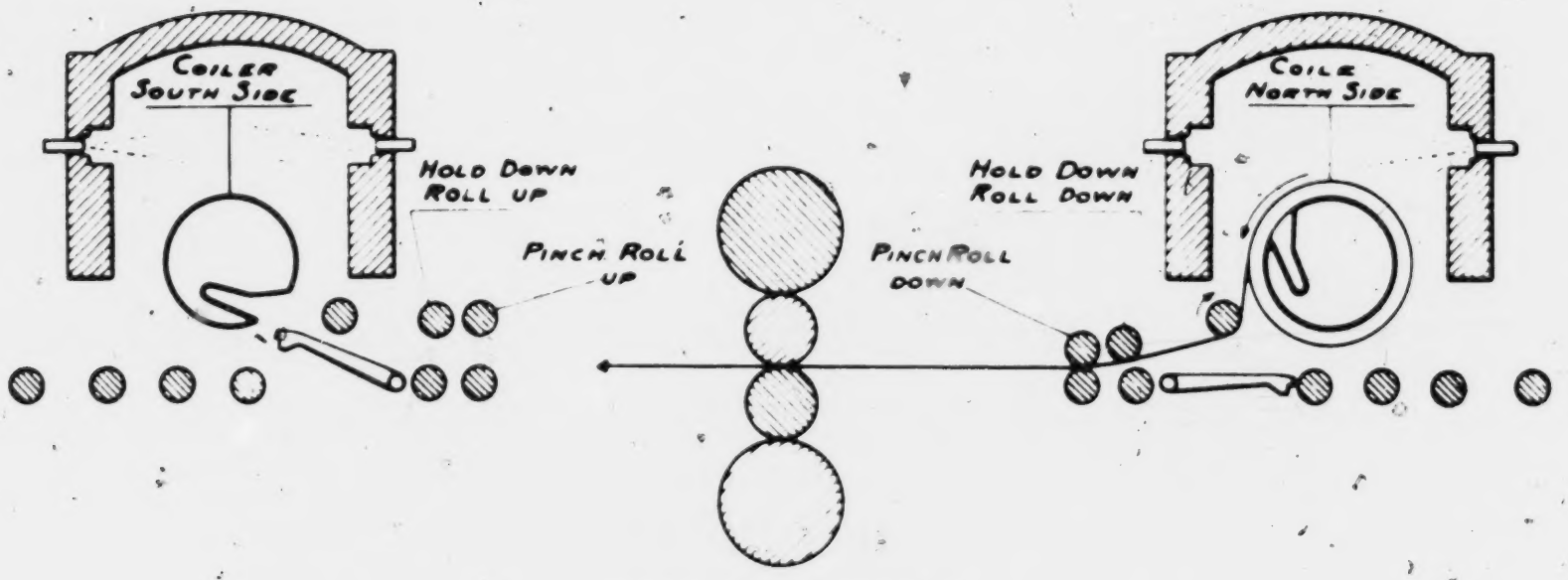
OPERATIONAL DRAWING NO. 9

NORTH →

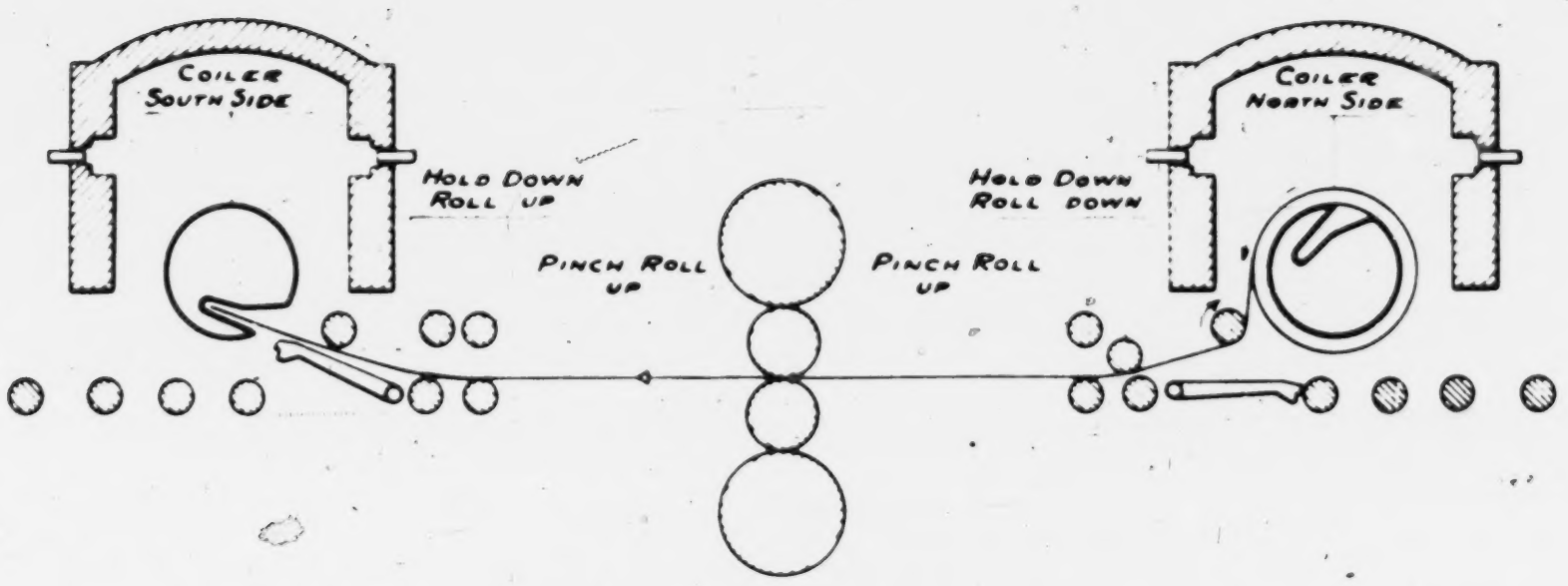
MODIFIED INSTALLATION



SECOND PASS COMPLETED



THIRD PASS STARTED



THIRD PASS ENTERING SOUTH COILER

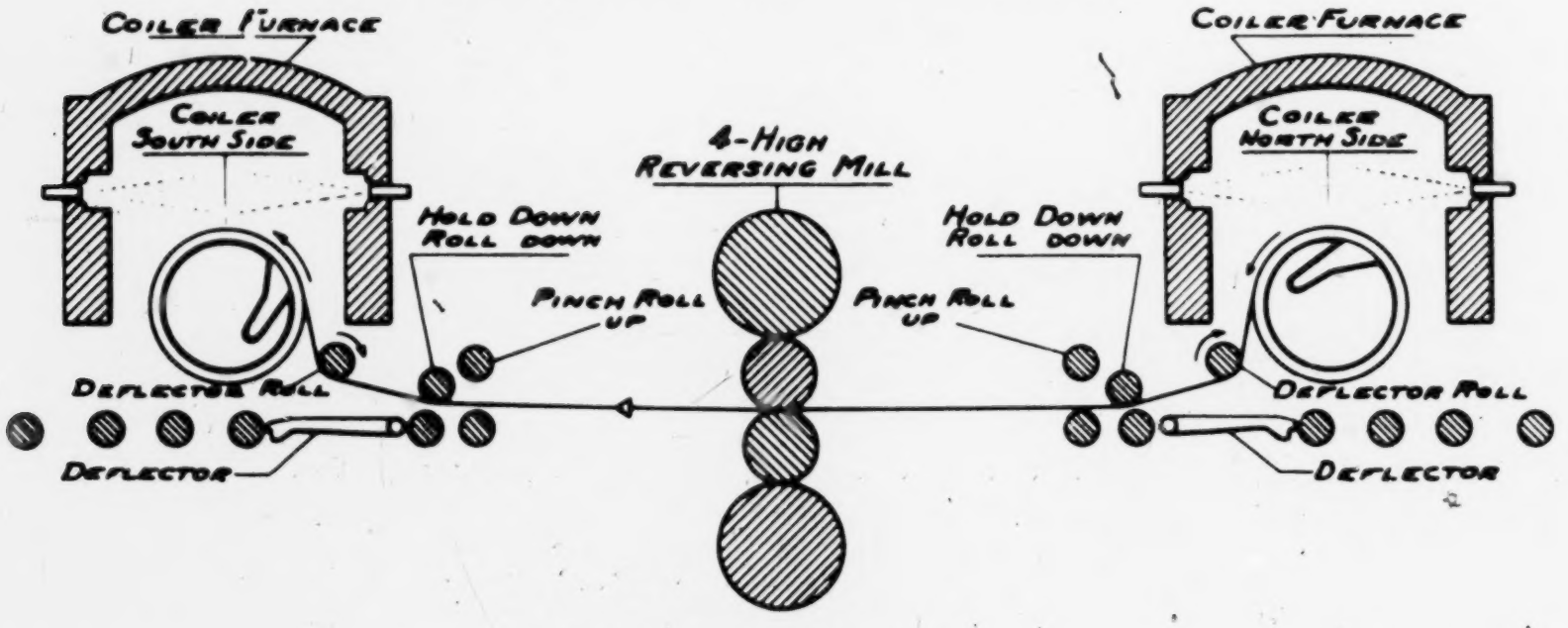
A 20

CRUCIBLE HOT STRIP MILL

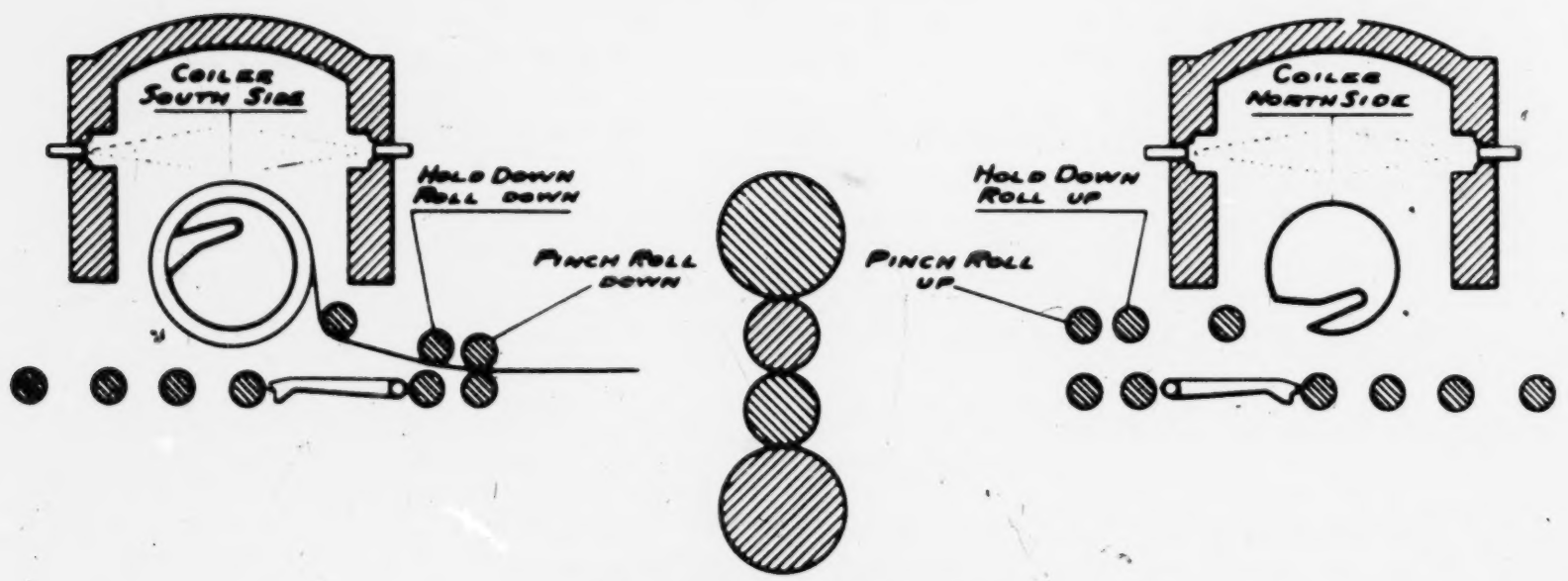
OPERATIONAL DRAWING NO. 10

NORTH →

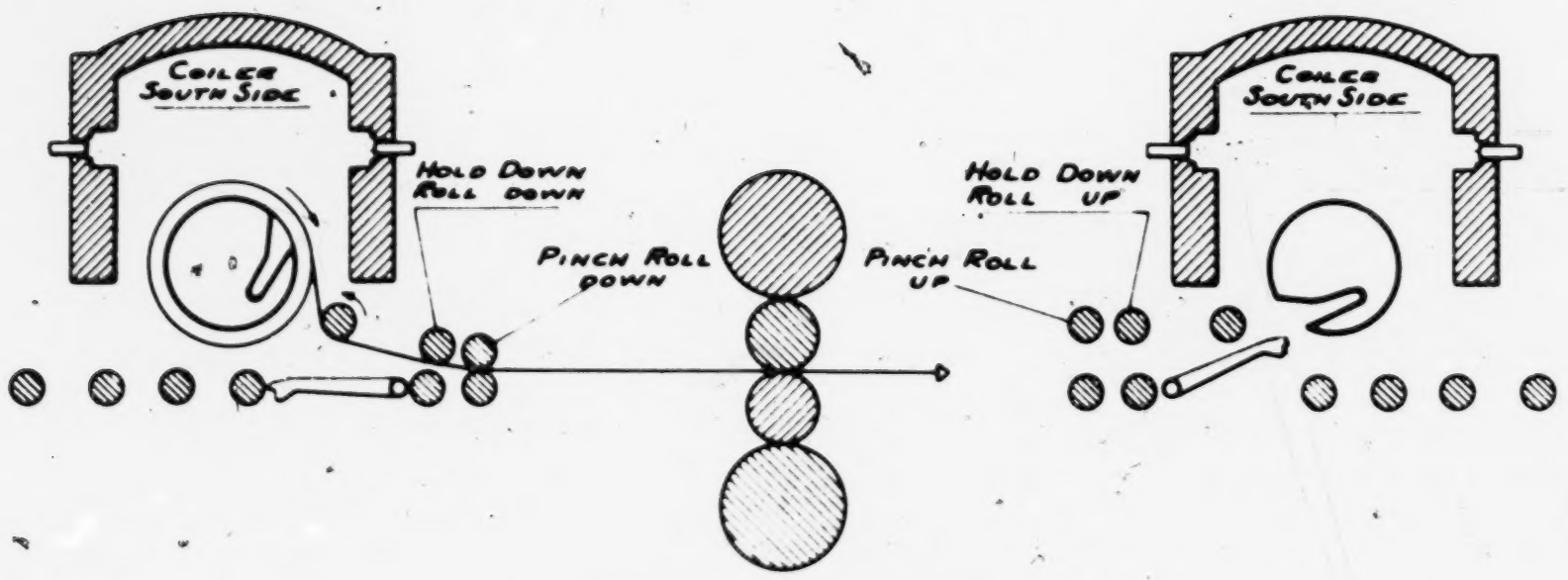
MODIFIED INSTALLATION



THIRD PASS ROLLING



THIRD PASS COMPLETED



FOURTH PASS STARTED

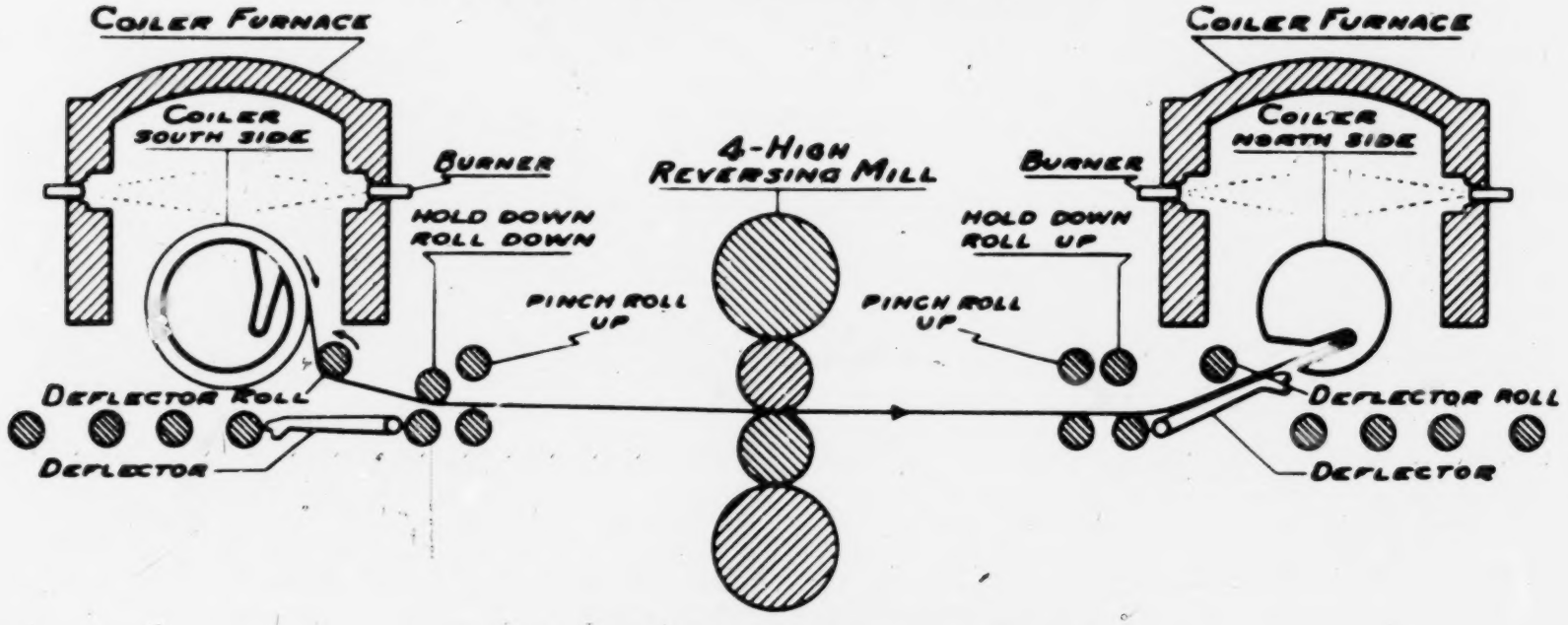
A 21

CRUCIBLE HOT STRIP MILL

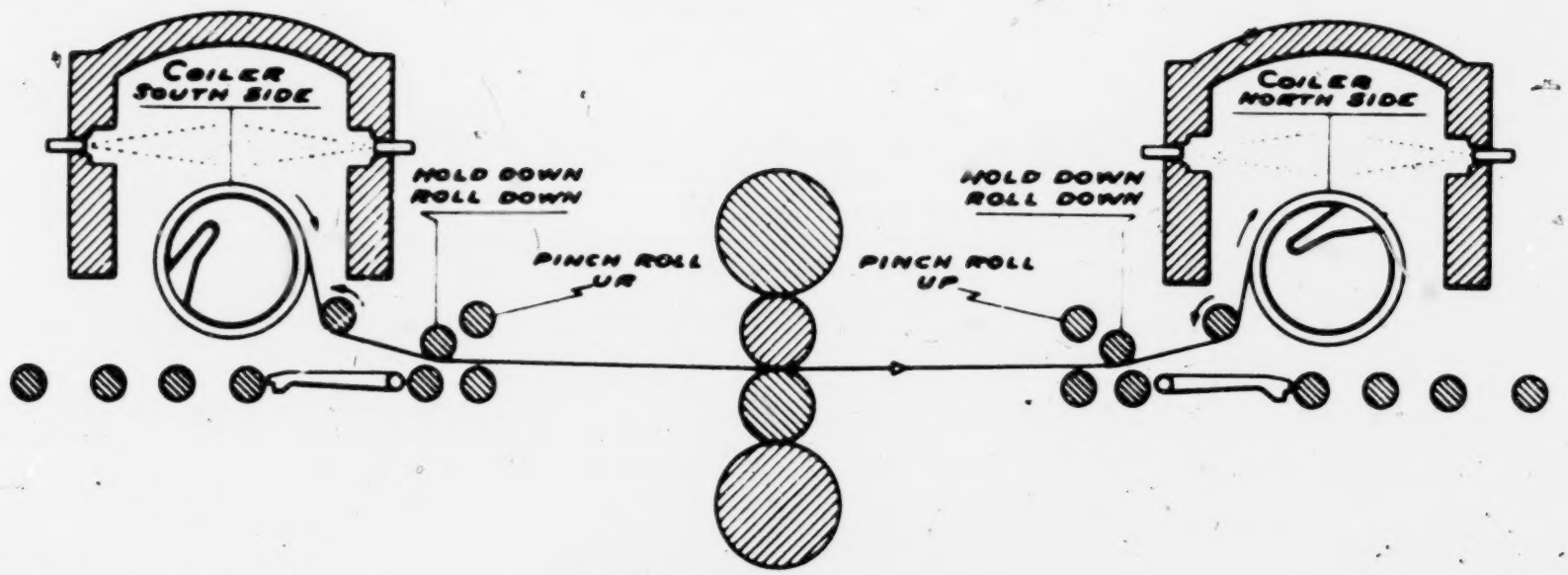
OPERATIONAL DRAWING NO. 11

NORTH →

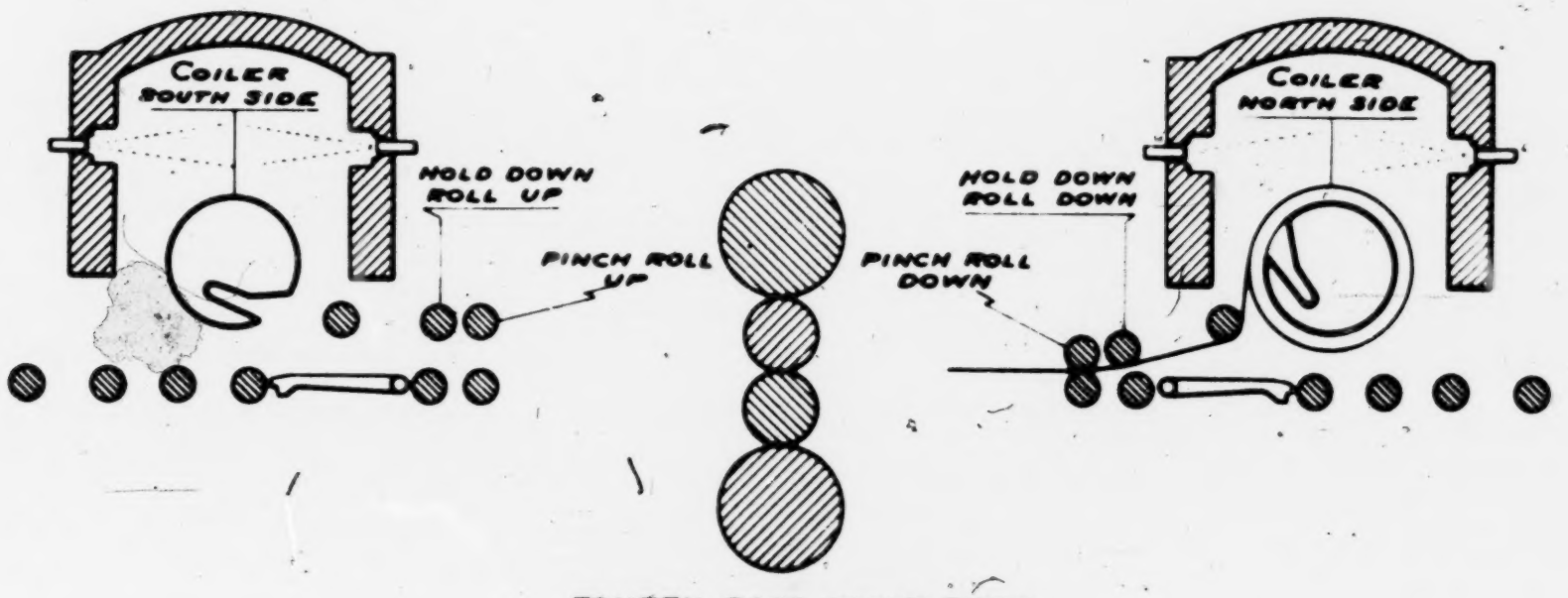
MODIFIED INSTALLATION



FOURTH PASS ENTERING NORTH COILER



FOURTH PASS ROLLING



FOURTH PASS COMPLETED

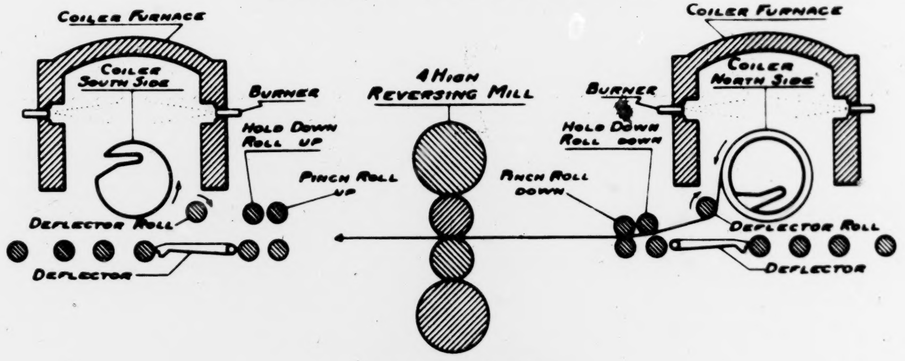
A 22

CRUCIBLE HOT STRIP MILL

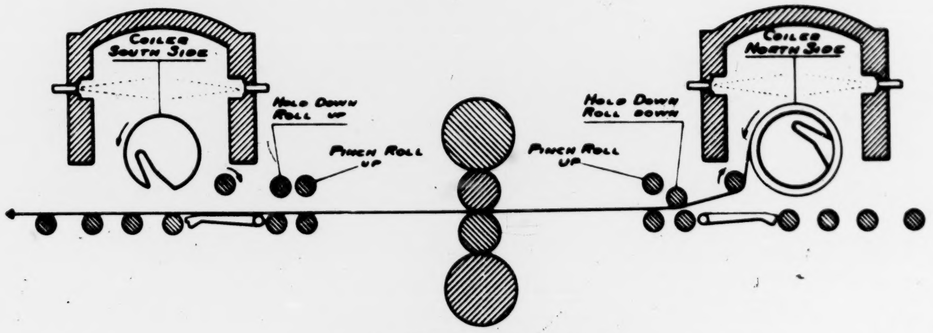
OPERATIONAL DRAWING NO. 12

NORTH →

MODIFIED INSTALLATION



FINAL PASS STARTED

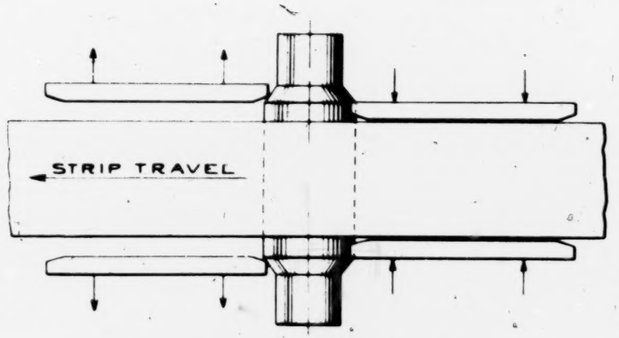


FINAL PASS DURING ROLLING

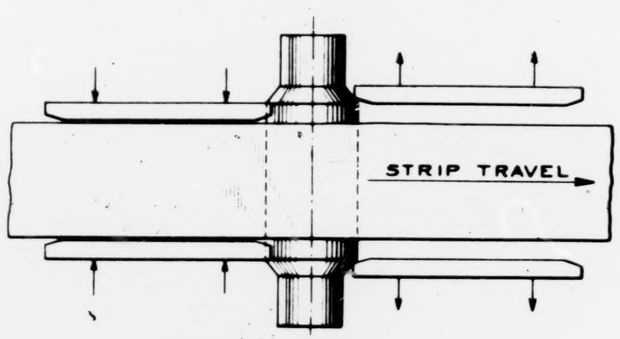
A 23

CRUCIBLE HOT STRIP MILL

SIDE GUIDE POSITIONS DIAGRAMATICALLY ILLUSTRATED



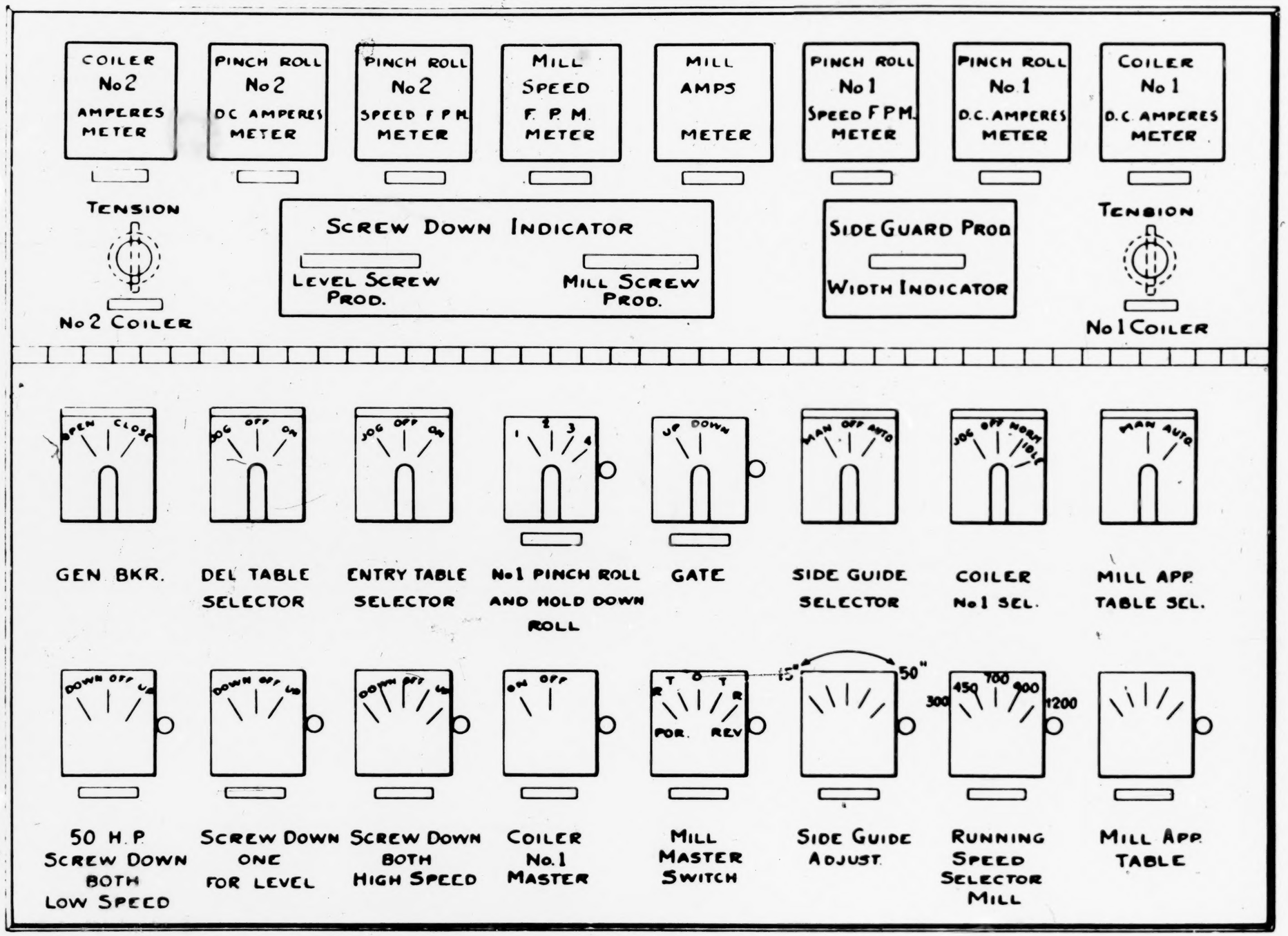
THREADING & RUNNING POSITIONS
TRAVEL TO LEFT



THREADING & RUNNING POSITIONS
TRAVEL TO RIGHT

CRUCIBLE HOT STRIP MILL

4HI REVERSING MILL OPERATOR'S DESK PANEL



CRUCIBLE HOT STRIP MILL

4 HI REVERSING MILL, ASSISTANT OPERATOR'S DESK PANEL

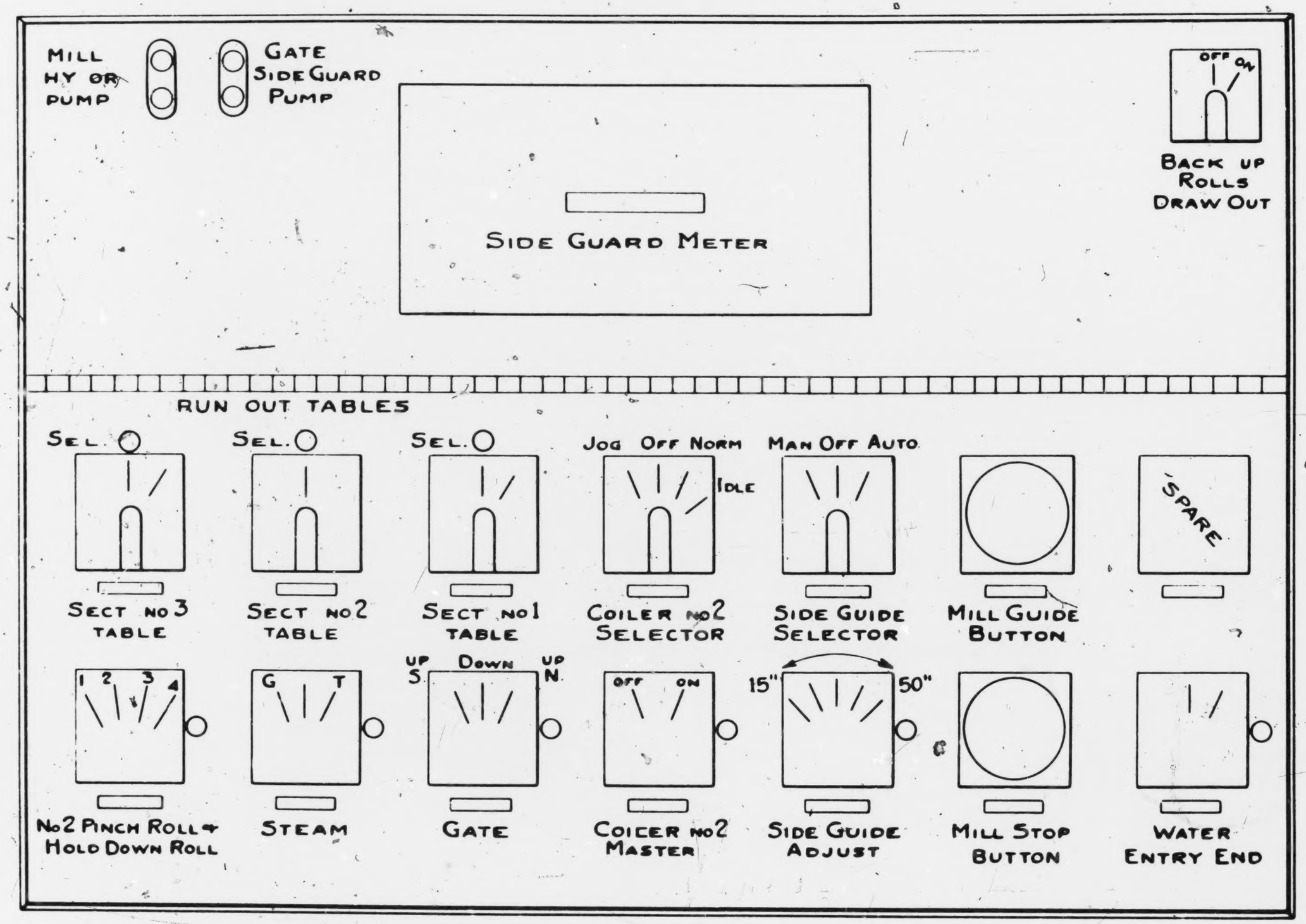


EXHIBIT D-7

5-Panel Fold-out Chart re Montgomery Patent 065

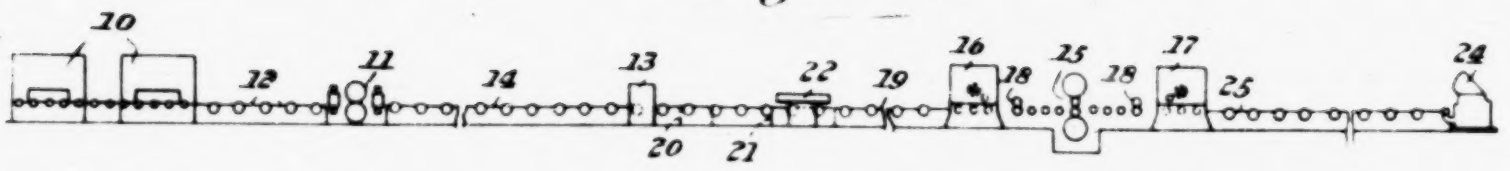
EXHIBIT D-7

July 13, 1937. **A. B. MONTGOMERY** **2,087,065**

METHOD AND APPARATUS FOR ROLLING

Filed Jan. 19, 1934

Fig. 2.



In the U. S. patent granted July 18, 1933 to Keeney, et al., No. 1,918,968, there is disclosed a four-high reversing mill with heating furnaces on opposite sides thereof for hot rolling strip. My invention is concerned chiefly with improvements upon the method and apparatus disclosed in said patent.

For certain classes of product, it is desirable to provide a finish on the hot strip superior to that which can be obtained with the mill shown in the Keeney patent, in which the entire reduction from the slab to the strip is effected by the same rolls.

*** * * * ***

In accordance with my invention, I take a slab after it has been properly heated in a suitable furnace and subject it to repeated passes through a universal mill to elongate it considerably without materially increasing its width. The ends of the piece are then sheared off to remove the ears projecting therefrom. The material is then passed into another reversing mill, e. g., that of the Keeney patent, with heating furnaces on opposite sides thereof, where it is subjected to further rolling with coiling between passes. After the material has been reduced sufficiently in the four-high mill, it is wound on a final coiler.

*** * * * ***

The operation of the apparatus above enumerated to perform the method of my invention may be described briefly as follows: The slabs are fed into the furnaces 10 to be heated prior to rolling in the mill 11. The slabs are initially 2" to 14" thick and of suitable width and length to provide the desired dimensions of finished hot strip. The heated slabs are passed back and forth through the universal mill 11, which effects a slabbing operation, until the slab is reduced to a thickness of ½" or less, with a corresponding elongation, and is cooled to a point where free scaling substantially ceases. The partially reduced slab is then forwarded to the four-high mill 15. The ends of the hot slab, however, are sheared off by the shear 13 before the piece arrives at the coiling mill.

AMENDMENT OF APRIL 27, 1937
(File Wrapper, pp. 41-42, 43)

(Submitting as claims 20-24 what became claims 1-4 of the patent)

REMARKS

This amendment is filed as a result of an interview accorded applicant's attorneys by the Principal Examiner and the Assistant Examiner on April 21st. At the interview, the above claims were discussed and it was agreed that they were allowable and that the filing of an amendment substituting them for the claims previously in the case would cause the application to be allowed. In order to complete the record, we include herebelow in brief form the argument which was presented to the Examiners orally at the interview.

The rejection on the ground that the claims defined the same method as that taught by Steckel and Keeney and that the only difference between the latter and applicant's method is in the apparatus, overlooks the fact that applicant's method differs from that of the references from the standpoint of mere manipulation if no other.

A method, simply defined, is a series of operations performed on material to produce a useful change in its condition. The method disclosed by Steckel includes the flat-rolling of a slab in a four-high reversing mill, and then rolling the resulting break-down on the same mill, with coiling between passes. In contrast to this, applicant reduces the slab to a break-down by flat-rolling in one mill and completes the rolling in another mill with coiling between passes. The results produced by applicant's method are superior to what can be achieved with the patented method, and this is a further argument for an actual difference between the two. We submit that the difference in the manipulation of the material and an improvement in the product are sufficient to remove all doubt as to the existence of a novel method.

* * * * *

The present invention deals with an improvement of the Steckel method wherein the roughing of a slab into breakdown is done in the same heat as the finishing of the breakdown into a strip by rolling in the Steckel mill, but the rough rolling is performed in a preliminary or roughing mill. At first glance, this might seem to be a step backward in the art, viz., providing an additional mill to do work which heretofore was done in the same mill which performed the finish rolling. The time required for roughing is less than that necessary for the coiling passes. Applicant finds, nevertheless, that the provision of special roughing mill is advantageous, despite the cost thereof including, not only the mill but the driving motor and the control equipment. This means, however, that the finishing mill can operate at maximum efficiency at all times, being confined exclusively to high speed rolling with coiling between passes and not periodically converted from a high-speed strip metal [mill] to a slow speed-slabbing mill in accordance with the disclosure of the Steckel patent.

C. B. CUSHWA.

METHOD OF ROLLING SHEET METAL.

APPLICATION FILED AUG. 18, 1905.

904,605. Patented Nov. 24, 1908

FIG. 1

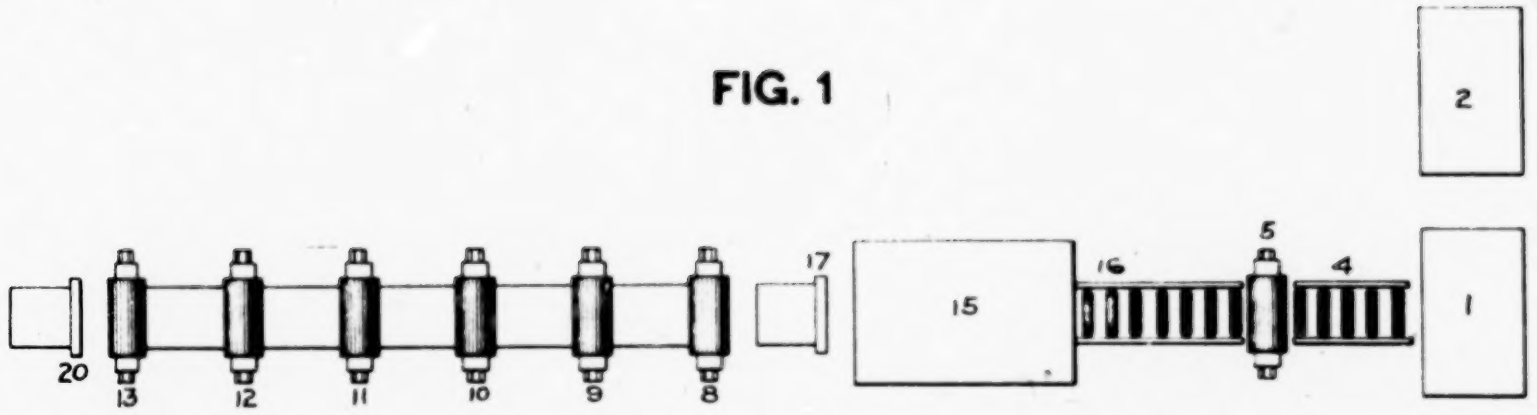


FIG. 2

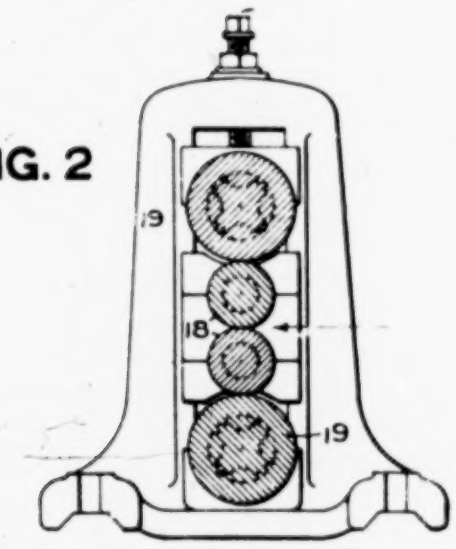
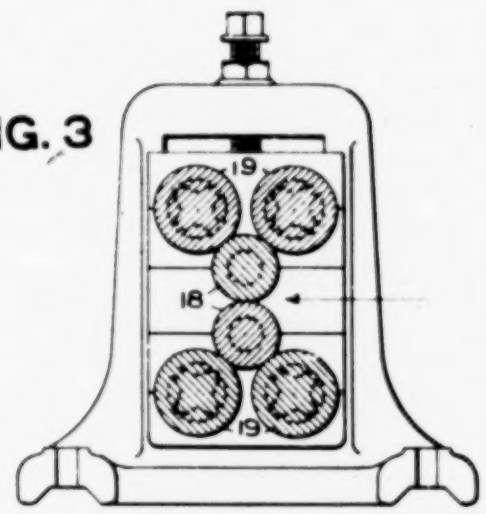


FIG. 3



My invention relates to a method of rolling metal in the form of thin sheets or strips, and its object is to provide a method whereby the many reheatings and the many manipulations and handlings of the metal employed in ordinary processes are dispensed with, thereby greatly reducing the cost of production; one wherein the amount of scrap produced is very largely reduced, and one wherein both faces of the sheet are subjected to the action of rolls, thus giving a bright and smooth surface on both sides.

* * * * *

It consists, generally stated, in starting with an ingot, billet or slab, roughing the same down to approximately ¼ inch or less in thickness, and then while still at the same heat passing the plates so produced singly through tandem mills consisting of a sufficient number of stands of small sized rolls to reduce the same to finished gage.

* * * * *

1, 2 and 3 represent suitable heating furnaces wherein the ingot, billet or slab is heated to a suitable rolling temperature. From these furnaces the heated ingot, billet or slab is transferred to the feed table 4 of the roughing down mill 5. The latter can be either a 2-high reversing mill or a 3-high mill. The heated ingot, billet or slab is passed back and forth through the mill 5 in well understood manner until it is reduced to a plate of approximately the width of the sheet to be formed and from about one quarter to a half inch thick.

* * * * *

The ingot, billet or slab is much cheaper to produce than the sheet bars heretofore necessary. Furthermore, it can be roughed to the gage specified at a single heat, and its gage is still such that the plate holds sufficient heat to enable it to be reduced to finished gage in the tandem or continuous mills represented by the rolls 8, 9, 10, 11, 12 and 13. To guard against delays on these finishing rolls I prefer to run the plate as it emerges from the mill 5 into a furnace 15, suitable live rolls 16 being employed to convey the plate through said furnace. In this furnace the plate, if delayed, is maintained at a good rolling heat, even though it be delayed a considerable time before entering the finishing mill. A shear 17 is provided for clipping off the front ragged end of the plate before entering the finishing mill. The finishing mill is shown as composed of six stands of rolls arranged in tandem, but the number thereof may be greater or less than this number, and in any event will be sufficient to reduce the plate to the finished gage.

* * * * *

The tandem mills are of the form shown in Figs. 2 and 3 in which the reducing rolls 18 are of comparatively small diameter. In order to give these small sized rolls sufficient stiffness each is backed by one or two large rolls 19, Fig. 2 showing one such backing roll and Fig. 3 showing two. The small sized rolls 18 have only a small area of contact with the metal being reduced, hence they press more deeply into, and more rapidly reduce or stretch the metal, than do the large diameter rolls usually employed in sheet mills. The small area of contact between such rolls and the plate also has the effect of reducing the amount of heat absorbed from the plate so that the latter is maintained at a better rolling heat than if larger rolls were used. The plate, after being roughed down is still very close to the initial heat of the blank, that is, a good bright red heat, and the further reduction thereof in the tandem mill described is effected so rapidly and with such a small absorption of heat by the rolls, that the plate reaches practically the thinnest gages before the temperature falls below a dull red.

* * * * *

What I claim is:

1. The method of rolling sheet metal, which consists in heating a suitable blank, and without further heating reducing the same to 20 gage United States standard, or thinner, by subjecting the same to successive rolling actions applied to small areas equally on both sides of the plate, thereby effecting the reduction at a temperature not less than a good dull red.

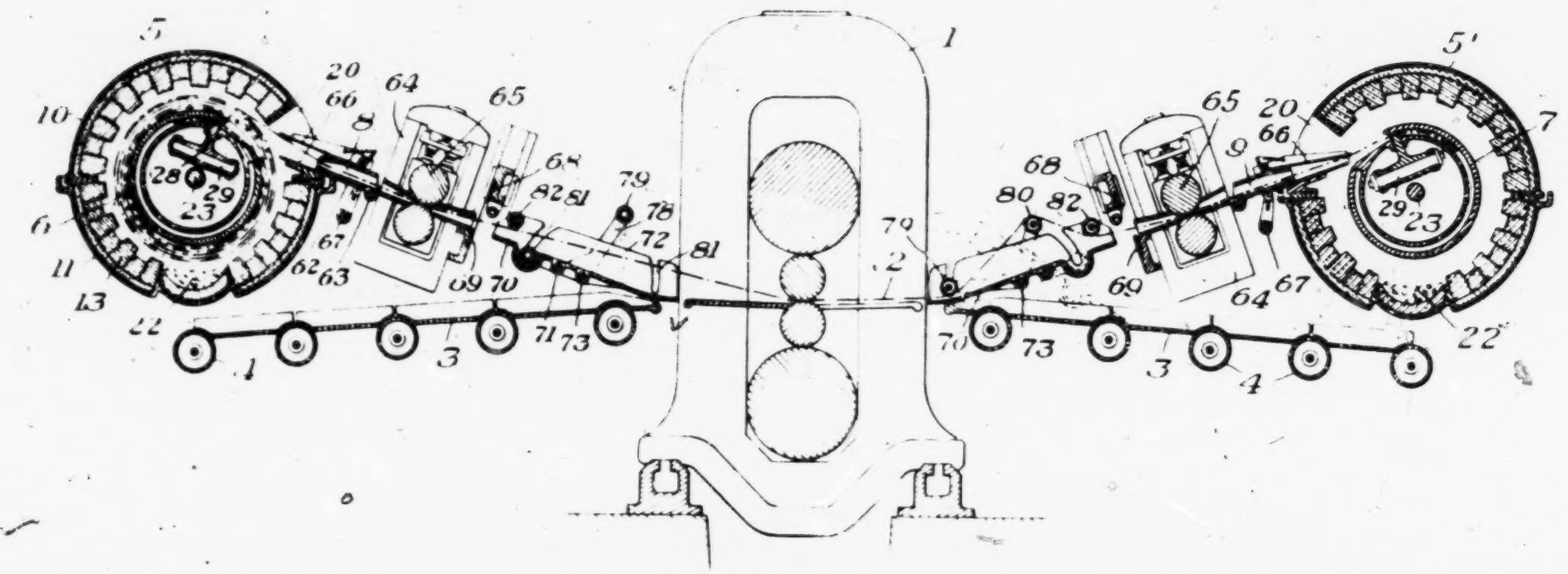
2. The method of rolling metal sheets, strips and the like, which consists in heating an ingot, billet, or slab, reducing the same by rolling and without further heating to a plate approximately ¼ to ½ inch thick, and then at the same heat reducing the same to finished gage by subjecting the same to successive rolling actions applied to small areas equally on both sides of the plate.

July 18, 1933. R M KEENEY ET AL 1,918,968

ROLLING MILL

Filed Jan. 12, 1928

FIG. 1



It is the primary object of the present invention to provide means whereby long and thin strips can be heated effectively and economically during the process of rolling, and therefore can be reduced to any thinness attainable by hot rolling, and the entire operation, after the initial roughing down, can, if desired, be carried out in a single stand of rolls.

* * * * *

The usual feed-tables 3 having driven rollers 4 are shown on the opposite sides of the stand of rolls 1.

* * * * *

Below the shear and extending into proximity to the stand of rolls 1 each of the chutes 8 and 9 has a tilting section 70 centrally mounted upon a rock-shaft 71. This tilting section has a floor and preferably opposite side walls 72. The tilting sections are provided so that they may be swung to a horizontal position, on one side of the rolls 1 to admit the strip coming from the roughing rolls of the mill, and on the other side to deliver the finished strip. Or if desired both sections may be swung out of the way and the strip be given one or more passes through the rolls 1 before it enters the chutes and coilers. Also by tilting either section to the position shown in dotted lines at the right hand side of Figure 1, any crop ends cut off by the shears can be delivered upon the roller table 3 and disposed of without delaying the operation of the mill.

* * * * *

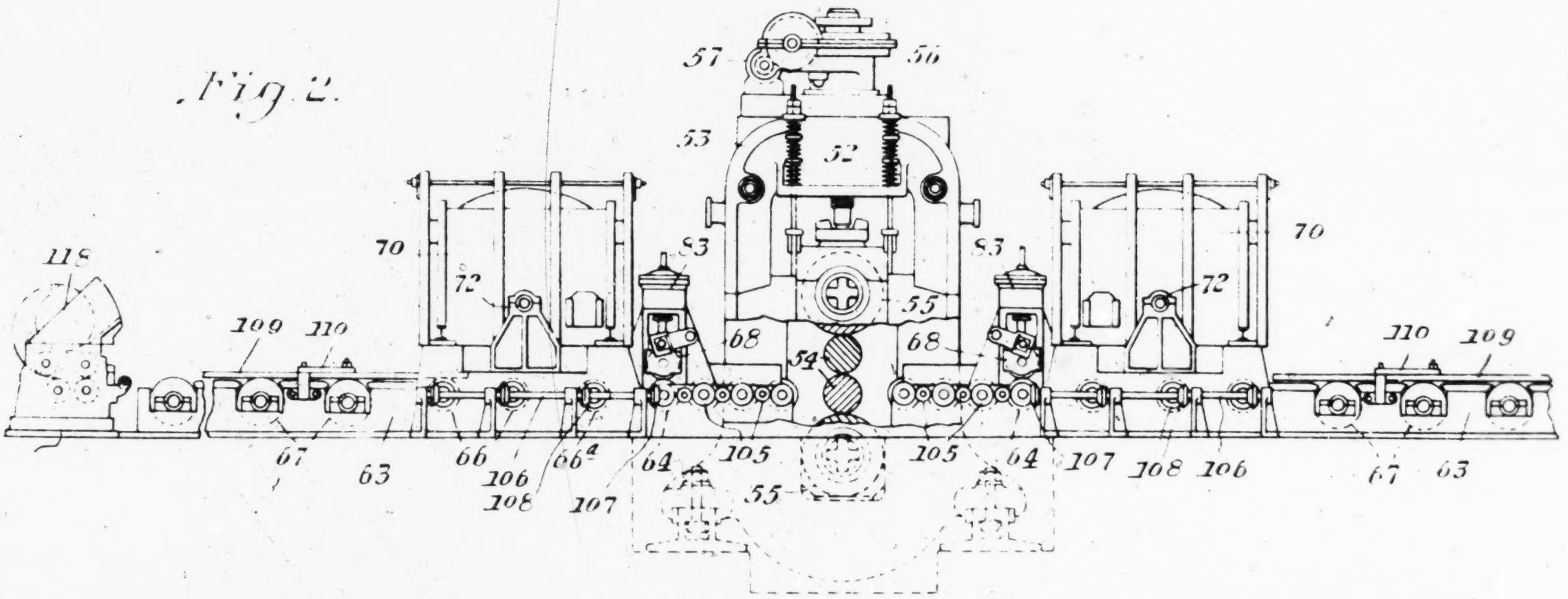
In operation, assuming that the table 3 at the right-hand side of Figure 1 leads from the roughing mill, the roughed-down strip will be carried on this table into and through the initial pass between the reducing rolls 1, which also act to feed the strip up the chute at the left and between the pinch-rolls, which are being driven at that time and which feed the strip on into the coiler, the guide 62, 66 being in advanced position to direct the leading end of the strip into the slot 25 in the reel. As soon as the leading end of the strip enters the slot 25 it is locked by the bar 28, and the coiler motor is started and the strip is wound on the reel, the pinch-roll motor being stopped and the driving shaft disconnected by opening of its magnetic clutch, so that during the winding operation the pinch-rolls act as idle guide rollers.

Oct. 16, 1934. A P STECKEL 1,977,214

METHOD AND APPARATUS FOR HOT ROLLING STRIP METAL

Filed May 4, 1931

Fig. 2.



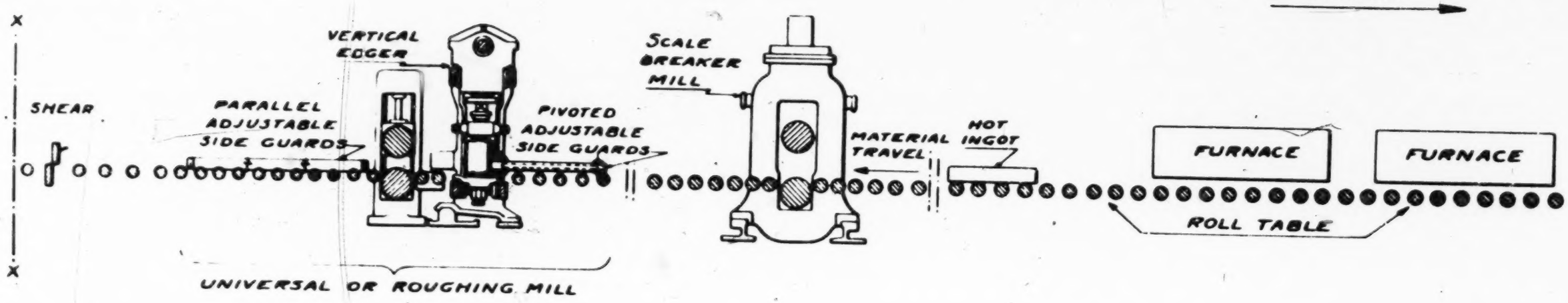
I provide a mill which is relatively simple and compact in construction, employing preferably but a single reducing stand, although it may in certain instances be desirable to divide the work between two stands.

* * * * *

I overcome these difficulties by initially hot rolling a piece of metal in the flat so as to reduce it in thickness sufficiently to permit of coiling it, and in the same heat feeding it from the coil and further reducing it. I preferably employ coilers on each side of the mill and after the initial flat rolling the material is coiled and uncoiled on each pass, the material being fed from a coil to the mill and being coiled up on the other side as it issues.

CRUCIBLE HOT STRIP MILL
DIAGRAMMATIC SECTION OF COMPLETE MILL

(D-7, J)



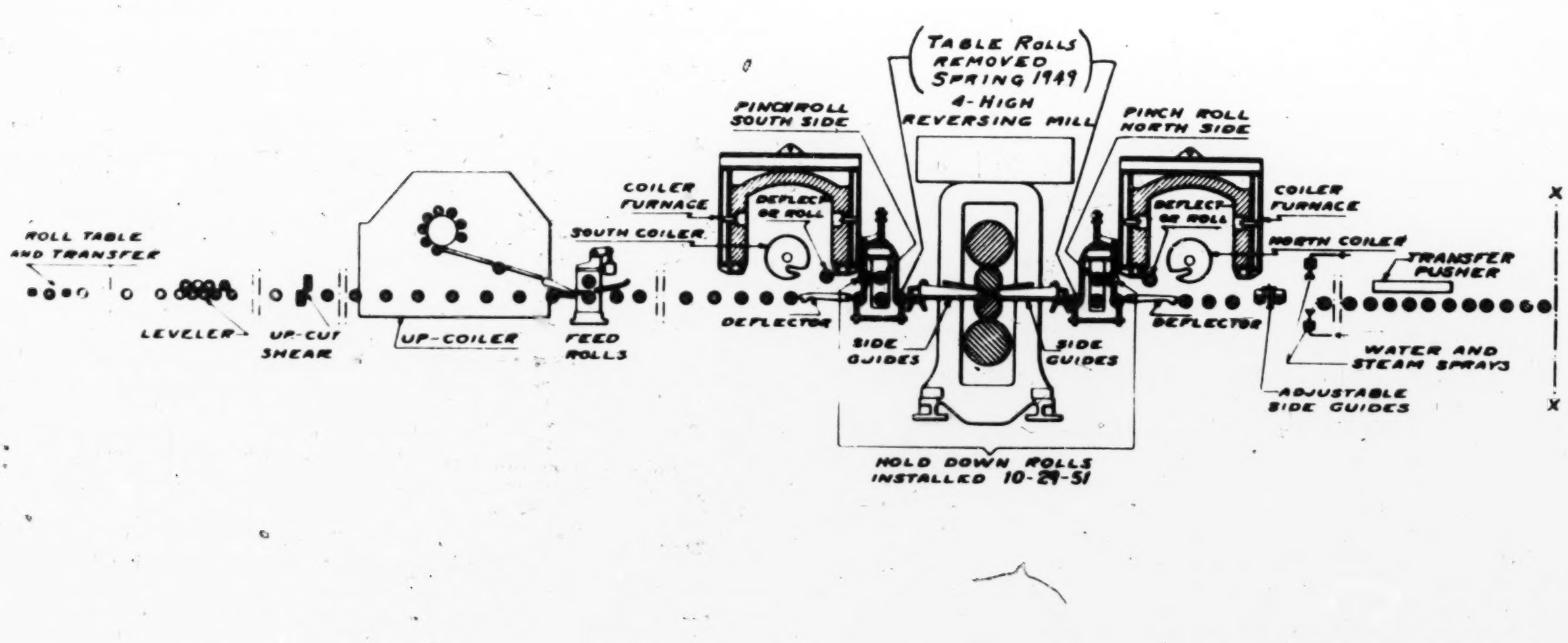


EXHIBIT D-8

ınel Fold-out Chart re Side Guide Control, Claim 10 of Montgomery 122

EXHIBIT D-8

March 2, 1937. A B MONTGOMERY 2,072,122

ROLLING MILL

Filed Dec. 4, 1934

Fig. 1.

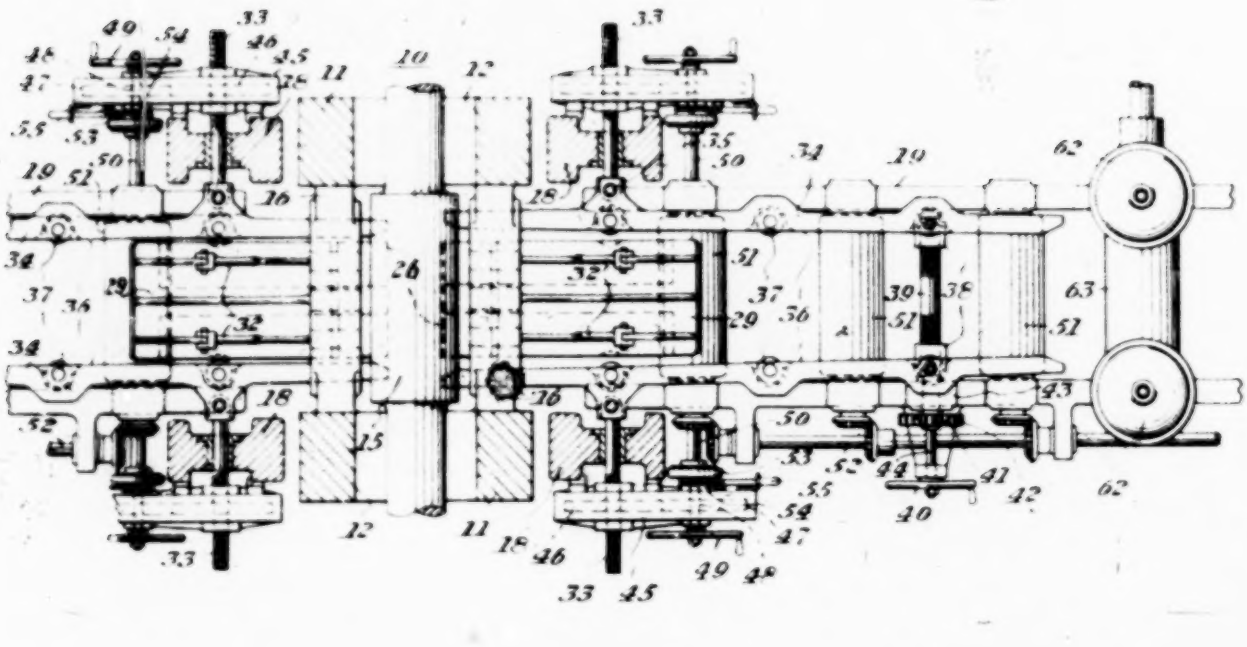
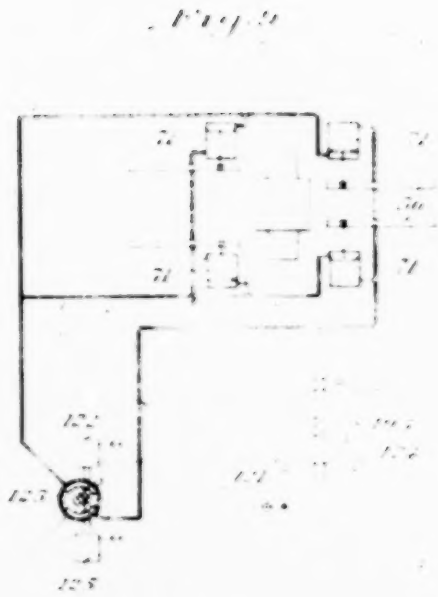


Fig. 9.



I have invented a rolling mill which overcomes the above mentioned disadvantages of the known mill construction. In accordance with my invention, I provide side guides on both sides of the mill and operate the guides successively to provide a parallel guiding throat on the entering side of the mill and a tapered guiding throat on the other side of the mill. The conditions of the guides on the two sides of the mills are reversed automatically by a change in the direction of the movement of the piece. Means are provided for adjusting the guides initially to cooperate with material of any desired width within the range of a particular construction.

* * * * *

Screw shafts 33 are slidably mounted in the housing 18 parallel to the axes of the mill rolls. Side guides 34 are supported on the screw shafts 33 by hinged joints 35. The guides 34 have a plane inner surface 36 with recesses into which anti-friction rolls 37 are let. The mill ends of the guides extend to a point closely adjacent the rolls, as shown in Figures 1 and 2. The outer ends of the guides are pivotally supported on nuts 38 traveling on a screw shaft 39 journaled in the side frames of the table 19. The ends of the screw shaft 39 are oppositely threaded so that on rotation of the shaft, the outer ends of the guides are moved toward or away from the center line of the table 19.

From what has been said, it will be apparent that my invention provides side guides which may be disposed in parallel relation, as shown on the left-hand side of the mill in Figure 1, or in angular relation, as shown on the right-hand side of the mill in Figure 1, for the purposes, respectively, of definitely and positively guiding the leading end of an advancing strip into the rolls at the proper angle thereto, and providing a tapering throat for receiving the end of the piece as it emerges from the mill. I shall now describe the mechanism for operating the guide supports to bring about the proper relation of the guides at the proper time.

The outer ends of the guides may be adjusted toward or away from each other through the shaft 39, as already described. This adjustment is effected by a hand wheel 40 having a pinion 41 meshing with a gear 42 along the screw shaft 39. A suitable pedestal bearing 43 is provided for the hand wheel shaft 44. The outer ends of the guides 34 are adjusted manually to the proper spacing before commencing the rolling.

The adjustment of the inner ends of the guides 34 is effected through the screw shafts 33. Gear cases 45 attached to the housings 18 enclose gear wheels 46 having their bores threaded for engagement with the shafts 33, and pinions 47 keyed to shafts 48. Hand wheels 49 permit manual adjustment of the screw shafts 33. These shafts are normally driven from extensions 50 of the shaft of one of the rolls 51 of the table 19. The rolls of the table are driven from a line shaft 52 through the usual bevel gears by a reversing motor, not shown. Between the shaft extensions 50 and the shafts 48 are positioned friction clutches 53 and jaw clutches 54 having operating levers 55. The purpose of the friction clutches is to permit the rotation of the shaft 48 to be arrested after a predetermined movement thereof without stopping the operation of the roll 51. The jaw clutches 54 permit the shafts 33 to be freed from the table drive while being manually adjusted.

The friction clutches 53 have detents 56 thereon cooperating with stops 57 on the housings 18 to limit rotation of the shaft 48 to the desired extent. After the detents engage the stops, the adjustment of the shafts 33 ceases but the roll 51 continues rotating with accompanying slippage of the clutches 53.

It will now be apparent that once the outer ends of the guides 34 have been adjusted, the inner ends of the guides will be spread to form a tapering throat or moved together to parallel position with the reversal of the drive for the rolls of table 19. The detents and stops controlling the amount of rotation of the friction clutches will determine the amount of movement imparted to the inner ends of the guides and may, if desired, be made adjustable. It will be understood, of course, that the guide-operating mechanism is designed so that the guides will be spread at the mill end when the table rolls are driven in such a direction as to move material away from the mill. At the same time, the guides on the opposite side of the mill will be actuated to parallel position. In this way, the material advancing toward the mill is definitely and positively alined at right angles to the plane containing the axes of the mill rolls. The emerging material is in no wise obstructed but is gently received within a slightly tapering guiding throat. In both cases, the anti-friction rolls 37 prevent binding and insure continuous, steady forward movement of the material without grabbing or slipping. As before stated, the extreme positions of the inner ends of the guides may be adjusted initially by hand after disengaging the clutches 54. Thereafter, the range of movement of the inner ends of the guides is determined by the location of the detents 56 and stops 57. In the construction illustrated, I have assumed that one complete revolution of the shaft 39 will produce the necessary movement of the inner ends of the guides.

Figure 9 shows how the side guide actuators of Figure 1A are controlled. When the controller 185 is shifted so as to cause the material to be fed from left to right, it closes contacts 121. It will be understood that operation of the controller also, through appropriate relays, causes the starting of the motor 183 in the proper direction. The closing of the contacts 121 energizes an operating magnet 122 for a valve 123. This valve is similar to that shown at 181 of Figure 8. The energization of the magnet 122 operates the valve to the position illustrated in Figure 9, in which it delivers fluid under pressure to the inner ends of the cylinders 71 on the exit (left-hand) side of the mill, and to the outer ends of the cylinders on the entering (right-hand) side of the mill. The guides 36 on the entering side are thus closed in, as indicated in Figure 9, while the guides on the exit side are opened to permit free passage of the material as it emerges from the mill.

On the reversal of the direction of rolling, for the next pass, the controller 185 bridges contacts 124 and energizes a magnet 125 to shift the valve 123 to the other position. The reverse operation of the cylinder 71 then takes place to close the guides on the left-hand side and open the guides on the right-hand side.

It will be understood that only a single controller 185 is employed and that it controls contacts 119 and 124, for example, simultaneously, in addition to the other contacts necessary to bring the motor 183 up to operating speed. The system of Figure 9 is shown separately from that of Figure 8 simply because it is a diagrammatic plan, whereas the latter is a diagrammatic elevation, but it will be understood that the two systems are combined and under the common control of the controller 185.

* * * * *

The positive actuation of the side guides under the control of the main controller causes the strip to be properly started toward the mill and correctly positioned with respect thereto before it actually enters between the mill rolls, after which no effort is sufficient to correct an improper starting of the strip, because of the great force exerted on the strip by the rolls.

* * * * *

10. The combination with a rolling mill having a driving motor and a controller for the motor, of adjustable side guides on both sides of the mill, and means operated by said controller for shifting the guides inwardly on the entrance side of the mill and outwardly on the exit side of the mill.

Oct. 16, 1934. A P STECKEL 1,977,214

METHOD AND APPARATUS FOR HOT ROLLING STRIP METAL

Filed May 4, 1931

Fig. 1.

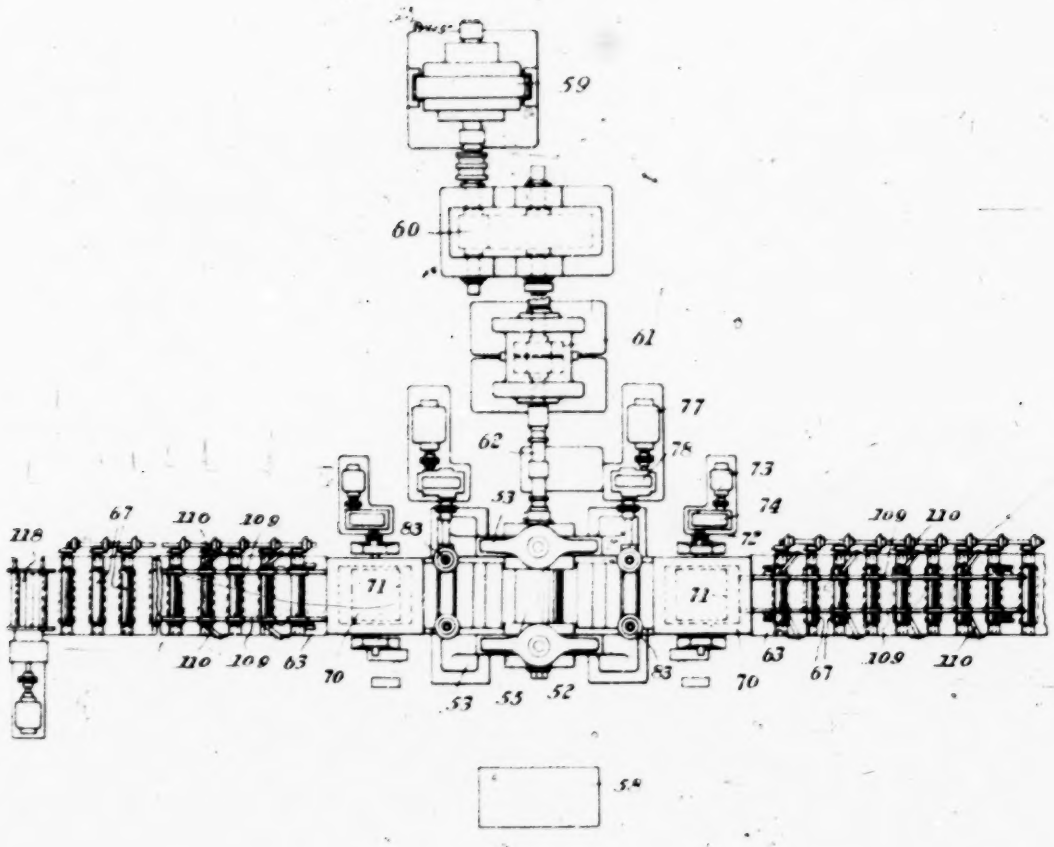
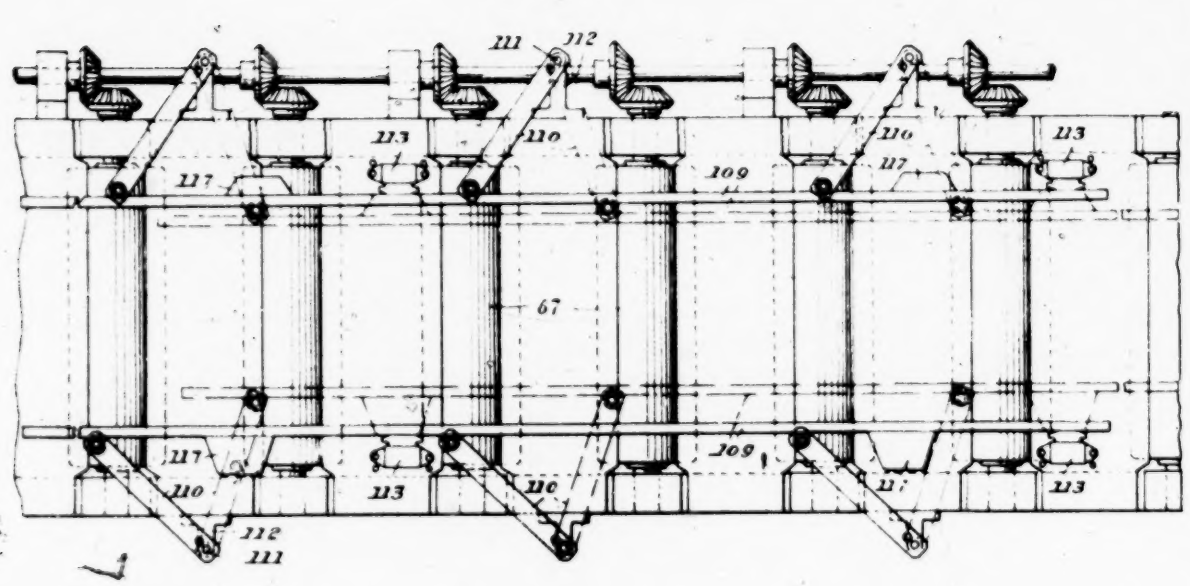


Fig. 6.



There are certain difficulties attendant upon rolling the material in the flat at the high speeds I contemplate, which difficulties must be overcome to make the installation desirable. As the material is reduced in thickness, it widens. In the early stages of rolling, where the slab is still relatively short, it is not so important that it be fed exactly squarely into the rolls, but as it increases in length its alinement becomes more and more important. In order to obtain such alinement, side guides must be employed, which side guides necessarily are spaced for entering the piece a distance only slightly more than the width of the piece being entered. On the exit side of the mill, however, the guides should have a relatively wider spacing in order to prevent cobbling. I provide automatically operable guides which fulfill these requirements.

* * * * *

The side guides comprise metal bars 109 connected to parallel links 110 pivoted at 111 on brackets 112 secured to the sides of the table. The bars 109 rest on the table rollers 67. The table shown in detail in Figure 6 lies at the left hand side of the mill as viewed in Figures 1 and 2, and the solid line position of the guides is their open position which is desired when receiving material. Assume now that a slab of metal to be rolled is lying on such table and it is desired to feed the same to the mill. The rolls 67 are rotated in such direction as to carry the metal to the right. By reason of the frictional engagement of the side guides 109 with the rollers, such guides are also carried to the right, swinging on the links 110. By reason of such movement they assume the position shown by dot and dash lines, and it will be noted that the guides in this position are much closer together and are effective for accurately alining the entering material. The further movement of the guides is limited by stops 113, which stops consist of casings 114 bolted to the mill table and carrying buffers 115 backed by coil springs 116.

When the rollers 67 are driven in the reverse direction the side guides are urged to the left as viewed in Figure 6 and swing back to the solid line position, their movement in this direction being limited by the side guides proper coming into engagement with the stops 113. The side guides are provided with pads 117 which engage the stops when the guides are at their inner position. The links 110 are provided with an extra hole or holes at their outer end through which they may be pivoted at 111 so as to vary their effective length and hence the spacing of the guides. The table is provided with a corresponding series of holes as shown in Figure 7, so that the stops 113 may be adjusted to correspond.

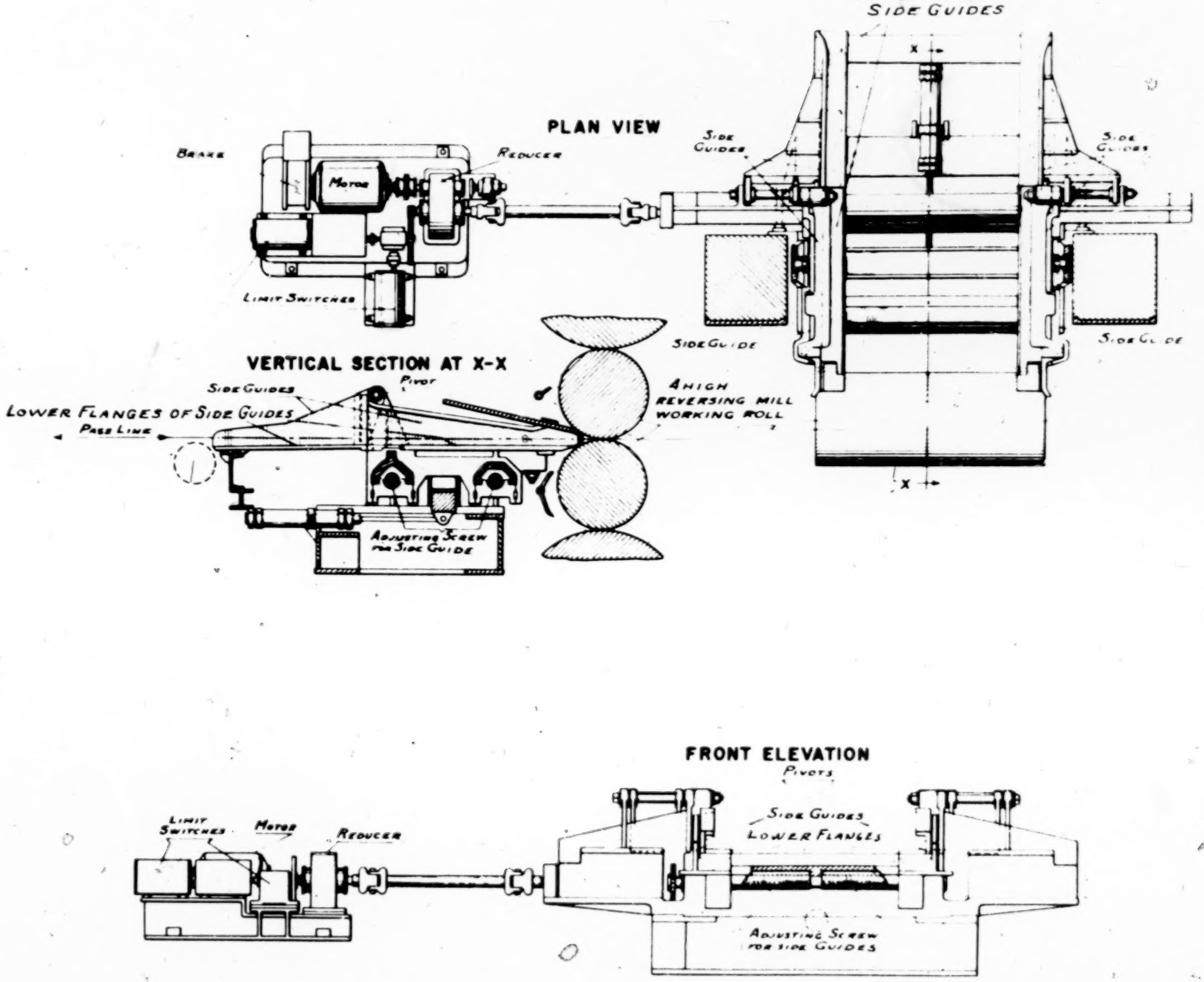
It will be noted that the initial angularity of the links on one side of the table differs from the initial angularity of the links on the other side of the table. The reason for this is that as the links move from the solid line to the dot and dash line position they move inwardly so long as the links are traveling toward a position of perpendicularity with respect to the axis of the table, and then slightly outwardly as the links move from such perpendicular position to their position of rest. If the initial angularity of the links on the two sides of the table were the same, such links might reach a condition of perpendicularity at the same moment, thus possibly bringing the guides so closely together as to interfere with the travel of the piece. However, this does not occur with the construction shown. On the contrary, the side guide shown at the upper portion of Figure 6 reaches its innermost position somewhat ahead of the guide on the opposite side. In so doing it engages the edge of the material and alines it. Then in coming to its position of rest it moves away from the material a slight distance so as to give it utter freedom of movement toward the mill, while limiting its sidewise movement to the slight clearance afforded by the travel of the links beyond their position of perpendicularity. The side guide shown at the lower portion of Figure 6 also engages the edge of the strip if the same is mis-alined, and thereby straightens it up for its travel into the mill.

* * * * *

6. In combination with a rolling mill, a table having rollers rotatable in either direction, a side guide movable on the rollers, and means for moving the side guide inwardly when the rollers rotate to move the guide in one direction and outwardly when they rotate to move it in the other direction.

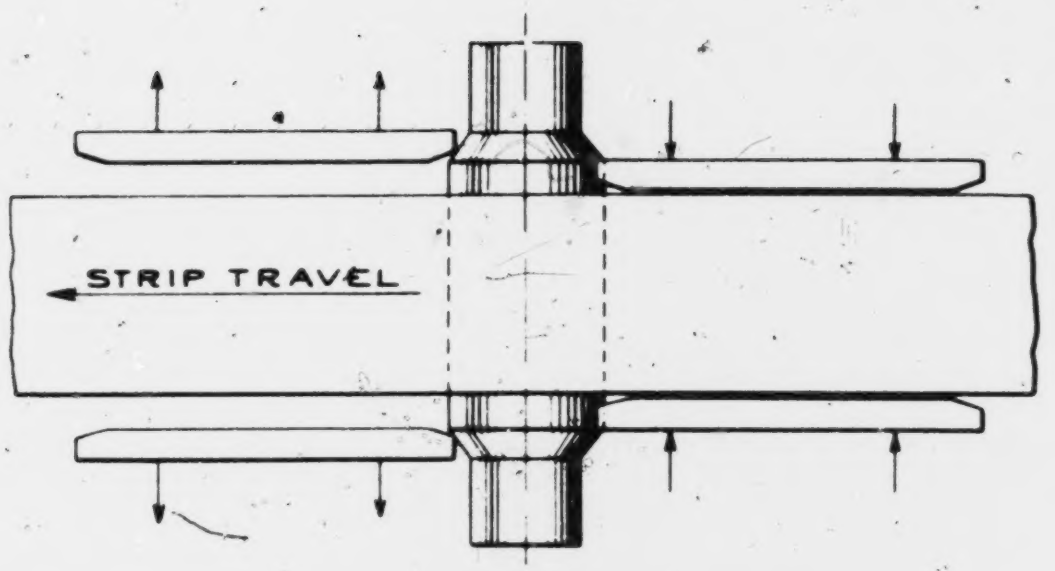
7. In combination with a rolling mill, a table having means for moving material therealong, and a side guide resting on the material moving means and movable therewith, means engaging the side guide arranged to move it laterally on actuation of the material moving means.

CRUCIBLE HOT STRIP MILL
SIDE GUIDE ASSEMBLY

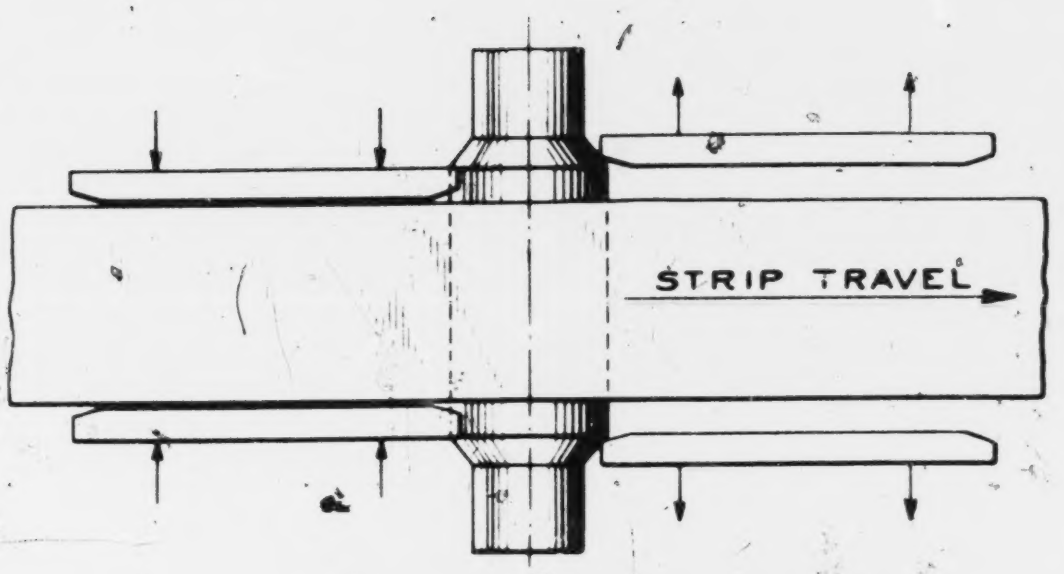


CRUCIBLE HOT STRIP MILL

SIDE GUIDE POSITIONS DIAGRAMATICALLY ILLUSTRATED



THREADING & RUNNING POSITIONS
TRAVEL TO LEFT



THREADING & RUNNING POSITIONS
TRAVEL TO RIGHT

EXHIBIT D-9

March 2, 1937. **A. B. MONTGOMERY** **2,072,122**

ROLLING MILL

Filed Dec. 4, 1934

Fig. 6.

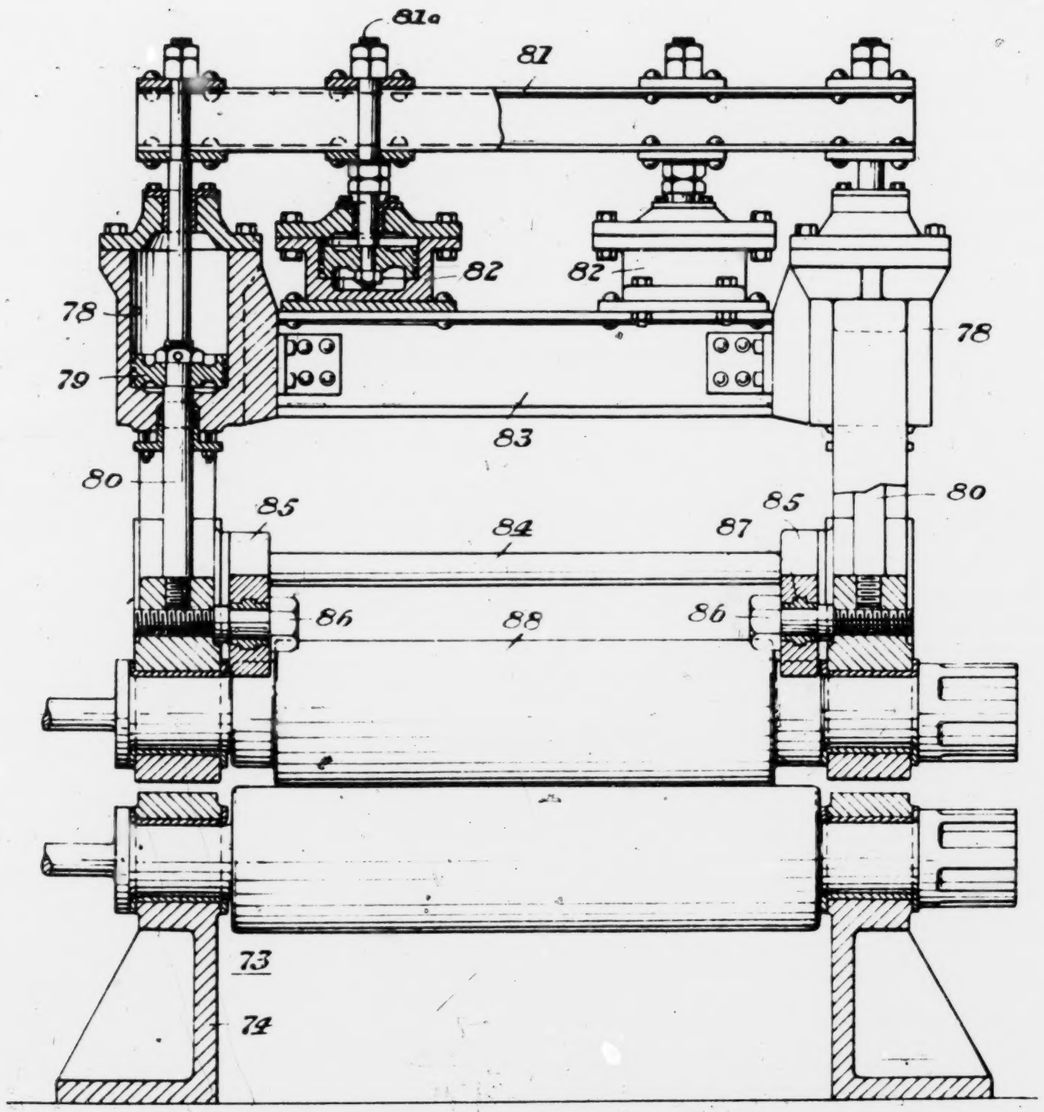
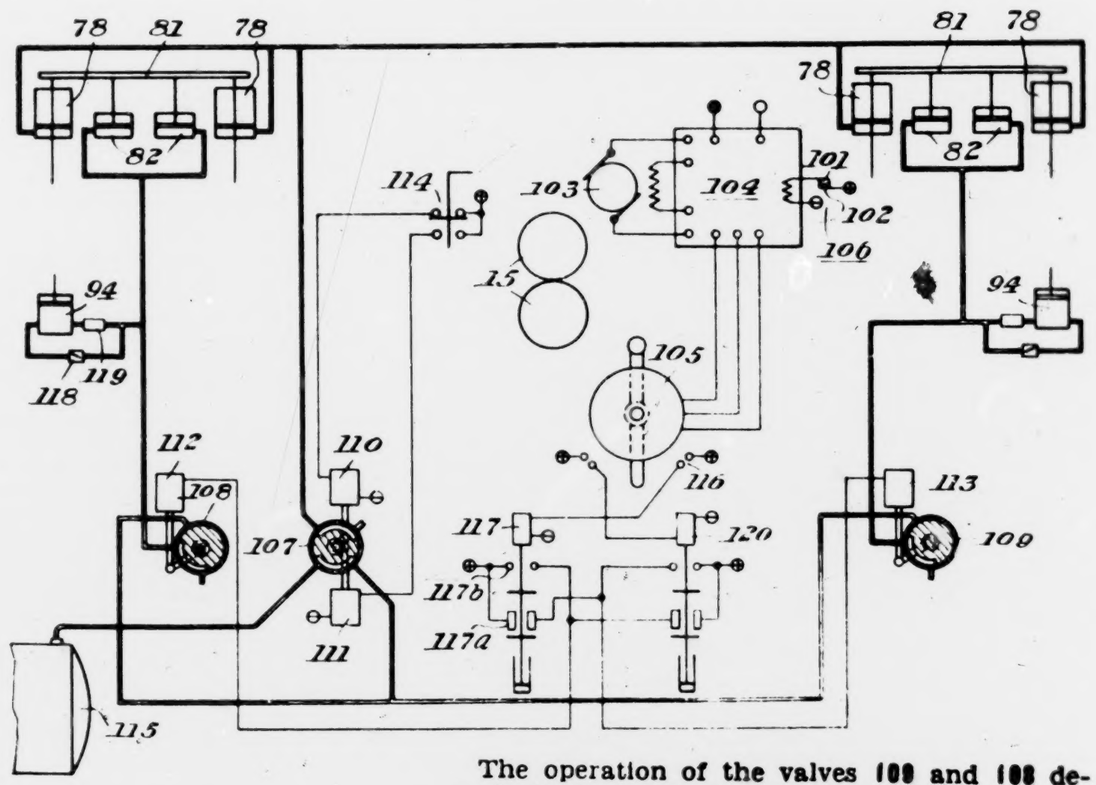


Fig. 8.



A modified form of construction of the auxiliary rolls for feeding and flattening the strip is shown in Figures 5 through 7. A roll table 73 has side frame castings 74. Housings 75 are attached to the castings 74 and have windows 76 therein in which bearing chucks 77 are slidable. Cylinders 78 formed in the upper part of the housings 75 have pistons 79 reciprocating therein. Piston rods 80 attached to the pistons 79 are threaded into the chucks 77 whereby the latter may be lifted to the dotted line position shown in Figure 5. Piston rods 80 extend outwardly through the upper end of the cylinders 78 and are connected by

When the thickness of the slab has been reduced to a point such that, on the next pass, the mill rolls are spaced apart only ¾" or less, the partially reduced material is sufficiently thinned and elongated to permit of coiling and, at the same time, its rigidity is such that the assistance of the pinch rolls is required to manipulate it through the mill and into the coilers. The limit switch 114 then closes its upper contacts to energize the magnet 110 and operate the valve 107 to the illustrated position. This vents the cylinder 78 and the pistons 79 immediately drop to lower the pinch rolls 88 onto the material. The pinch rolls are driven by any

The operation of the valves 108 and 106 described above, also causes the operation of the cylinders 94 on opposite sides of the mill. The roll 92 is thus raised into engagement with the material but is sufficiently spaced thereby from the roll 90 that the contact 101 remains in engagement with the contact 102. The fluid pressure is continuously applied to the cylinders 94 as long as the rolling continues but, unless the strip breaks during rolling, the rolls 90 and 92 are maintained separated and the contacts 101 and 102 remain in engagement. If the strip is broken, the roll 92 is immediately lifted into engagement with the roll 90, whereupon the rod 98 lifts the contact 101 to open the circuit for the relay 106 and thereby stop the motor 103.

When the pass is completed, the controller 105 is restored to neutral position so that the trailing end of the strip stops between the mill and the pinch rolls on the exit side thereof. The relay 117 is thus deenergized and substantially immediately opens its contacts to deenergize magnets 112 and 113. The cylinders 82 are thus exhausted to the atmosphere and the

A modified form of construction of the auxiliary rolls for feeding and flattening the strip is shown in Figures 5 through 7. A roll table 13 has side frame castings 14. Housings 15 are attached to the castings 14 and have windows 16 therein in which bearing chucks 17 are slidable. Cylinders 78 formed in the upper part of the housings 15 have pistons 79 reciprocating therein. Piston rods 80 attached to the pistons 79 are threaded into the chucks 17 whereby the latter may be lifted to the dotted line position shown in Figure 5. Piston rods 80 extend outwardly through the upper end of the cylinders 78 and are connected by cross beams 81. Cylinders 82 carried on a transom 83 extending between the housings, also have pistons and piston rods arranged as shown in Figure 6 whereby the beams 81 and, therefore, the chucks 17, may be raised through a small distance. The piston rods of the cylinders 82 have separable, abutting engagement with bolts 81a. It will be apparent that the cylinders 79 and 82 provide independent means for lifting the chucks 17 through a long stroke and a short stroke, respectively. The object of this arrangement will become apparent as the description proceeds.

An equalizing shaft 84 extends between the housings 15 and is journaled therein. Cranks 85 keyed to the shaft 84 carry trunnions 86 in slidable bearings blocks 87. The trunnions 86 are threaded into the chucks 17, as best shown in Figure 6. The equalizing shaft obviously serves to effect simultaneous and equal movement of both bearing chucks and prevents binding of the reciprocating mechanism.

* * * * *

The cylinders 79 and 82 are automatically controlled to cause the pinch rolls 88 and 89 to engage the material at certain times and to release it at other times.

In rolling a slab into strip on the mill 10, it is desirable that the pinch rolls 88 be withdrawn as long as the slab being reduced has sufficient rigidity to permit it to be fed back and forth to and from the mill by the friction of the table rolls. When the slab has been reduced to a gauge such that it has relatively little rigidity, or to a condition in which coiling between passes is advisable, the pinch rolls are advanced to assist in threading the strip through the mill at the beginning of each pass. While both ends of the strip actually pass through the mill, the pinch roll motors are so controlled that neither end of the strip is disengaged from the pinch rolls on both sides of the mill. At least one end of the strip is always engaged by at least one set of pinch rolls. It is by these pinch rolls that the strip is then fed back to the mill for the next pass. On the exit side of the mill, the pinch rolls assist in delivering the leading end of the strip into the coiler by pushing it up the guide 22.

* * * * *

When the thickness of the slab has been reduced to a point such that, on the next pass, the mill rolls are spaced apart only ¾" or less, the partially reduced material is sufficiently thinned and elongated to permit of coiling and, at the same time, its rigidity is such that the assistance of the pinch rolls is required to manipulate it through the mill and into the coilers. The limit switch 114 then closes its upper contacts to energize the magnet 110 and operate the valve 107 to the illustrated position. This vents the cylinder 78 and the pistons 79 immediately drop to lower the pinch rolls 88 onto the material. The pinch rolls are driven by any convenient means, at the same peripheral speed as the rolls 15, so as to cooperate therewith in moving the material back and forth.

If it is assumed for the sake of explanation that the breakdown formed from flat rolling the slab was reduced on a pass from left to right, to a gauge such that after the next reduction, it would be less than ¾" thick, as soon as the top roll 15 is lowered to within less than ¾" of the bottom roll, the described operation of the valve 107 will take place and the pinch rolls will seize the breakdown for the next pass from right to left. When all is ready for this pass, the roller operates the handle of the controller 105 to the left, as shown in Figure 8, whereupon the motor 103 is operated so as to drive the rolls 15 and roll the strip from right to left. The pinch roll drive is so coordinated with that of the mill that the pinch rolls 88 are simultaneously operated so as to assist in the feeding of the breakdown.

The movement of the controller 105 bridges contacts 116 to energize a relay 117. The relay 117 has a time delay in its operation, indicated by a dashpot, and after a certain time bridges contacts 117a to energize the magnet 113. The relay is adjusted so that the contacts 117a will be bridged just after the leading end of the breakdown being rolled passes between the rolls 15. The magnet 113 operates the valve 109 to admit fluid supplied through the valve 107 to the cylinders 82 on the entering side of the mill. The pinch roll 88 on that side is thus lifted from the material.

After a slightly longer time, the relay 117 operates to bridge its contacts 117b, maintaining the circuit for the magnet 113 by reason of the fact that the bridging contact slides along the contacts 117a. The relay is adjusted so that the contacts 117b are bridged after the material has emerged from the mill on the exit side, passed through the pinch rolls, and made one turn about the coiler. The bridging of the contacts 117b causes the operation of magnet 113 to shift the valve 108. The cylinders 82 on the exit side of the mill thus operate to raise the associated pinch roll from the strip. The strip is thus free between the winding and unwinding coilers, except where engaged by the mill.

94 as long as the rolling continues but, unless the strip breaks during rolling, the rolls 90 and 92 are maintained separated and the contacts 101 and 102 remain in engagement. If the strip is broken, the roll 92 is immediately lifted into engagement with the roll 90, whereupon the rod 98 lifts the contact 101 to open the circuit for the relay 106 and thereby stop the motor 103.

When the pass is completed, the controller 105 is restored to neutral position so that the trailing end of the strip stops between the mill and the pinch rolls on the exit side thereof. The relay 117 is thus deenergized and substantially immediately opens its contacts to deenergize magnets 112 and 113. The cylinders 82 are thus exhausted to the atmosphere and the pinch rolls dropped. At the same time, the cylinders 94 are exhausted through check valves 118, the weight of the roll 92 and chucks 93 serving to force the accumulated fluid out of the cylinders. The operating fluid for the cylinders 94 passes initially through expansion valves 119 which slightly delays the lifting of the chucks 93 on starting a pass.

The next pass is accomplished in exactly the same manner. Reversal of the controller 105 energizes the relay 120 and this, in turn, causes sequential lifting of the pinch rolls 88 on the entering and exit sides of the mill. This cycle is repeated until the strip has been reduced to the desired gauge, when it is wound on a coiler beyond the furnace on the exit side of the mill. The top work roll is then lifted by reversal of the screwdowns. The switch 114 closes its lower contacts and operates the valve 107 to admit fluid under pressure again to the cylinders 78, whereby the pinch rolls 88 on both sides of the mill are lifted out of the way for the next flat rolling operation.

* * * * *

6. In a rolling mill including a pair of housings and work rolls journaled therein, pinch rolls on one side of the mill, and means for raising one of the pinch rolls through a short distance, and independent means for raising the upper pinch rolls through a greater distance.

18. In a rolling mill, a pair of housings having work rolls journaled therein, pinch rolls on at least one side of the mill for engaging material being worked in the mill, means for retracting one of said pinch rolls when unused for a substantial period, and independent means for temporarily retracting one of said rolls.

19. The combination with a rolling mill and a roll table for advancing work thereto, of pinch rolls on one side of the mill, one of said pinch rolls being retractible, and means for retracting said roll including fluid pressure-operated cylinders and pistons, one of which has a short stroke for temporarily retracting the roll and the other having a longer stroke for retracting the roll when unused for substantial periods.

Oct. 16, 1934. A. P. STECKEL 1,977,214

METHOD AND APPARATUS FOR HOT ROLLING STRIP METAL

Filed May 4, 1931

(D-9, 2)

Fig. 4.

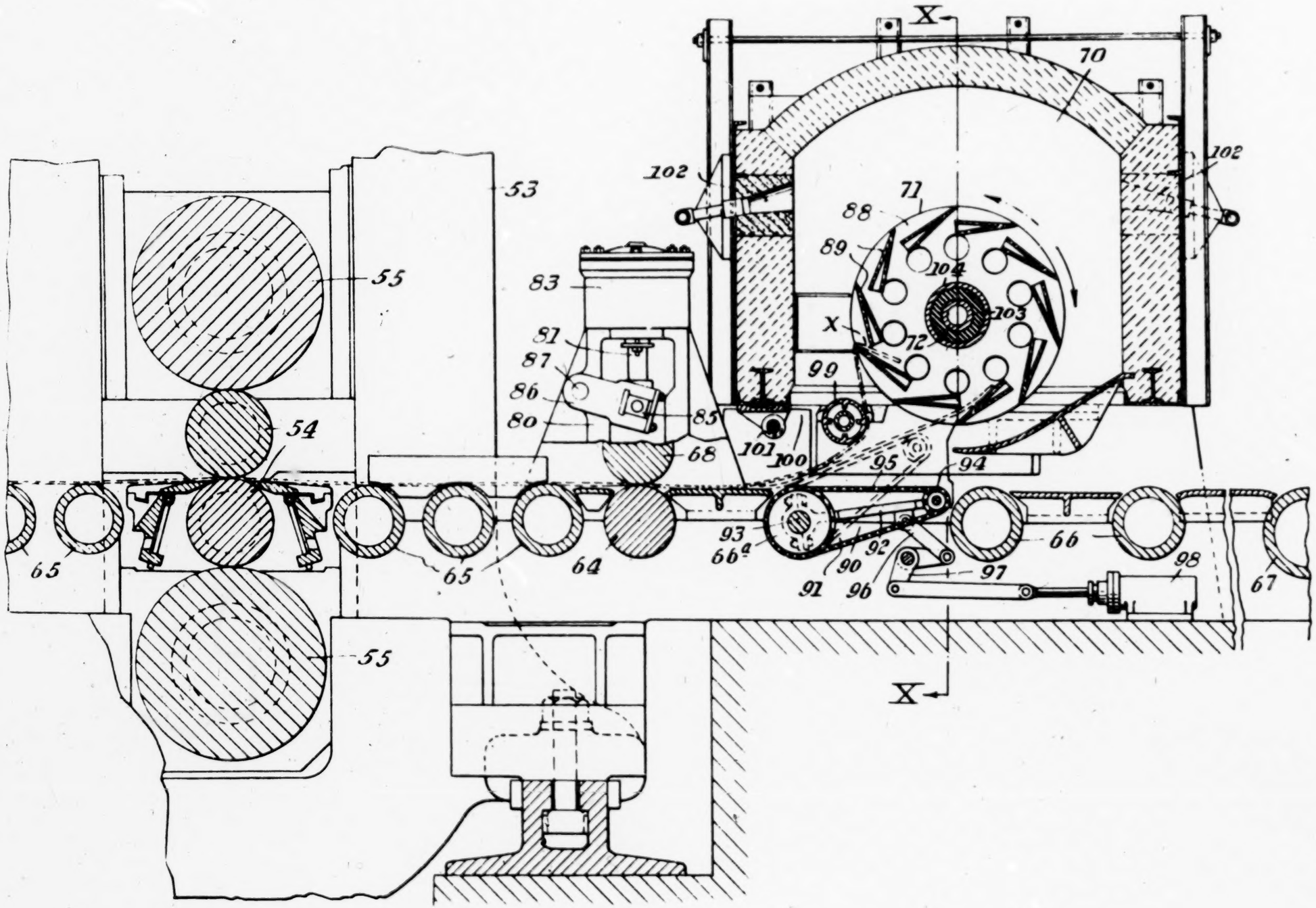
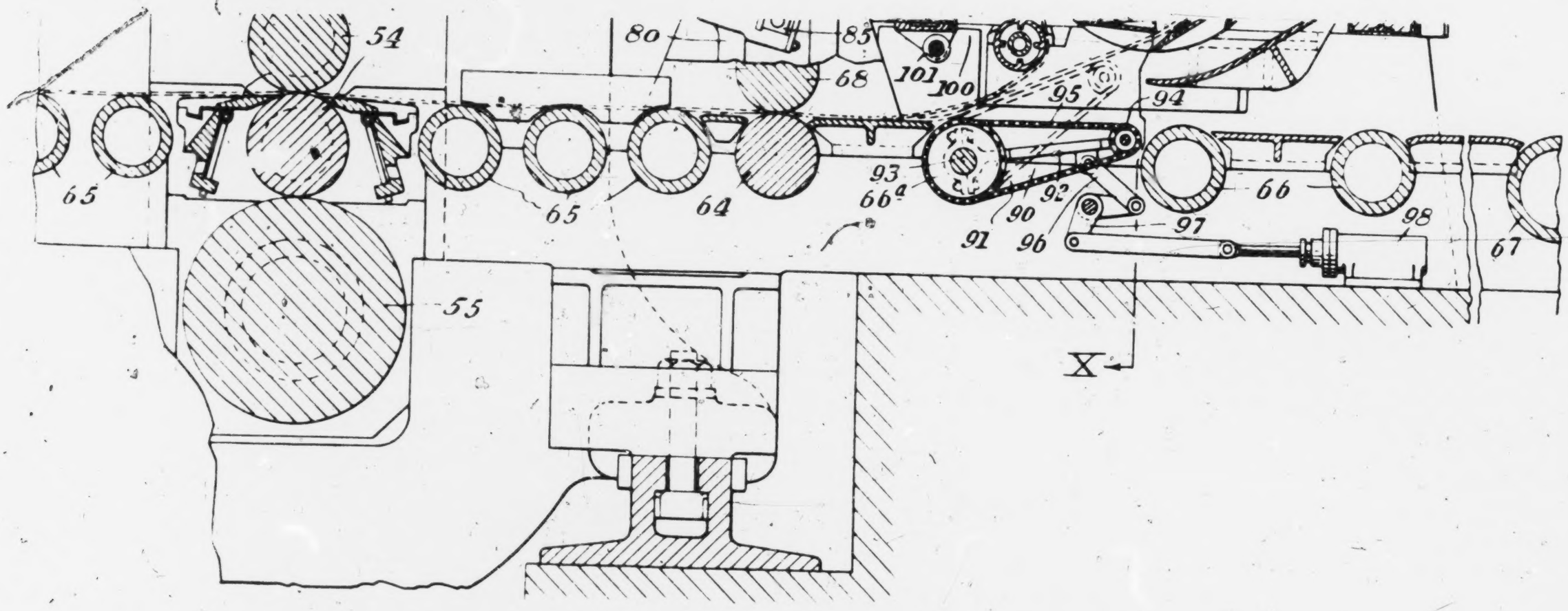


EXHIBIT D-9

**4-Panel Fold-out Chart re Double Lift Pinch Roll,
Claims 6, 18 and 19 of Montgomery 122**



The pinch rolls operate to maintain the material under tension and this is highly desirable. It insures straightness of the product and materially simplifies the handling. The pinch rolls on the exit side will be arranged to exert a forward pull on the material, and those on the entering side will be arranged to impart a drag thereto. This causes the material to issue straight. If there are any slight irregularities due to over-rolling at one point or another across the width of the strip, such irregularities will be largely or entirely removed.

* * * * *

The rolls 64 cooperate with rolls 68 to form a pinch roll unit effective for engaging material. The rolls 68 are arranged to be raised or lowered as desired

The pinch roll structure is best illustrated in Figures 4, 8 and 9. The rolls 64 are driven through coupling boxes 75 and spindles 76 from motors 77 (see Fig. 1) through reducing gears 78. The motors 77 are controlled from the operator's pulpit 58 as are the motors 73 and 59.

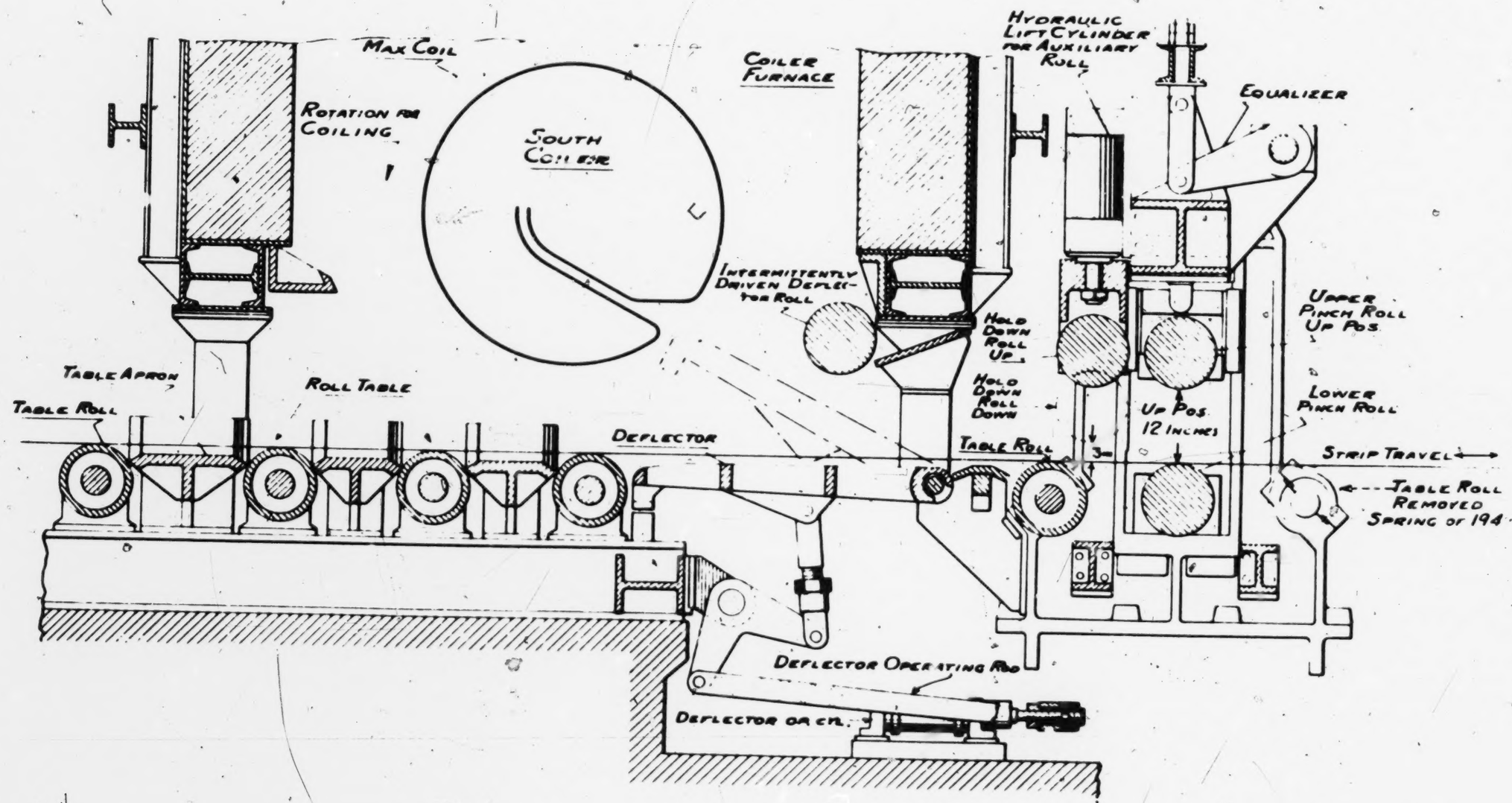
The rolls 68 are mounted in bearings 79 slidable in housings 80. A piston rod 81 extends upwardly from each bearing 79 to a piston 82 in a cylinder 83 formed in the upper part of the housing 80. The pistons 82 may be raised or lowered by controlling the supply of air to the cylinders 83. The movement of the cylinders is also controlled from the operator's pulpit 58. In order to insure simultaneous raising and lowering of the bearing 79 for each end of a roll 68, the bearings are interconnected. Each bearing carries a stud 84 extending through a block 85 slidable in the forked end of a lever 86. The levers 86 are keyed to a rocked shaft 87 so that the bearings 79 are bound to move up or down together.

CRUCIBLE HOT STRIP MILL

VERTICAL SECTION AT PINCH ROLL & COILER

MODIFIED INSTALLATION

(D-9, 3)



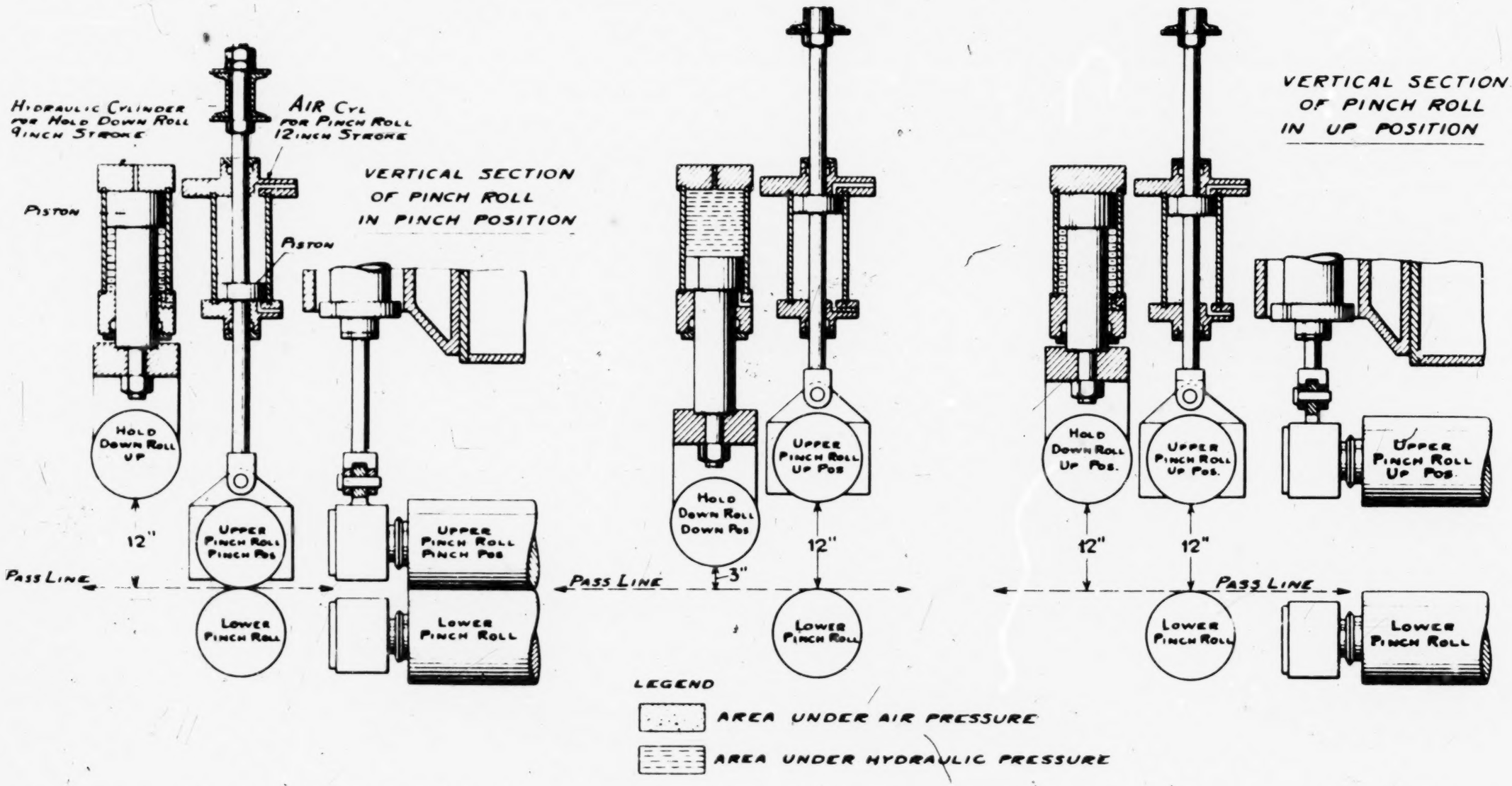
CRUCIBLE HOT STRIP MILL

PINCH ROLL & AUXILIARY ROLL ARRANGEMENT

MODIFIED INSTALLATION

A9

(D-9,2,4)



LEGEND

AREA UNDER AIR PRESSURE

AREA UNDER HYDRAULIC PRESSURE

EXHIBIT D-10

5-Panel Fold-out Chart re Claims 4 and 6 of Montgomery 107

(Acc 1 of 15)

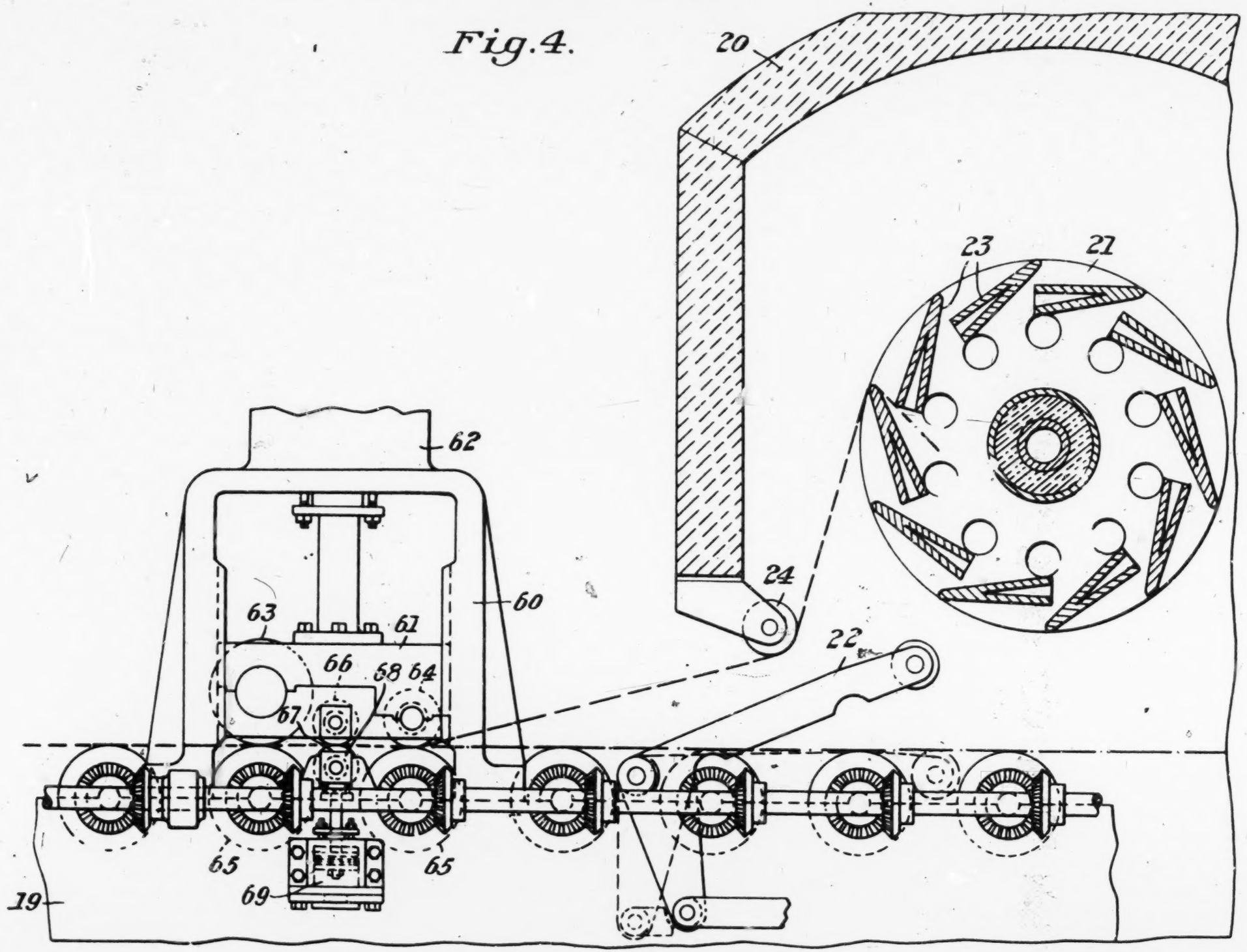
EXHIBIT D-10

Sept. 10, 1940. **A. B. MONTGOMERY** **2,214,107**

METHOD OF ROLLING

Filed Oct. 23, 1936

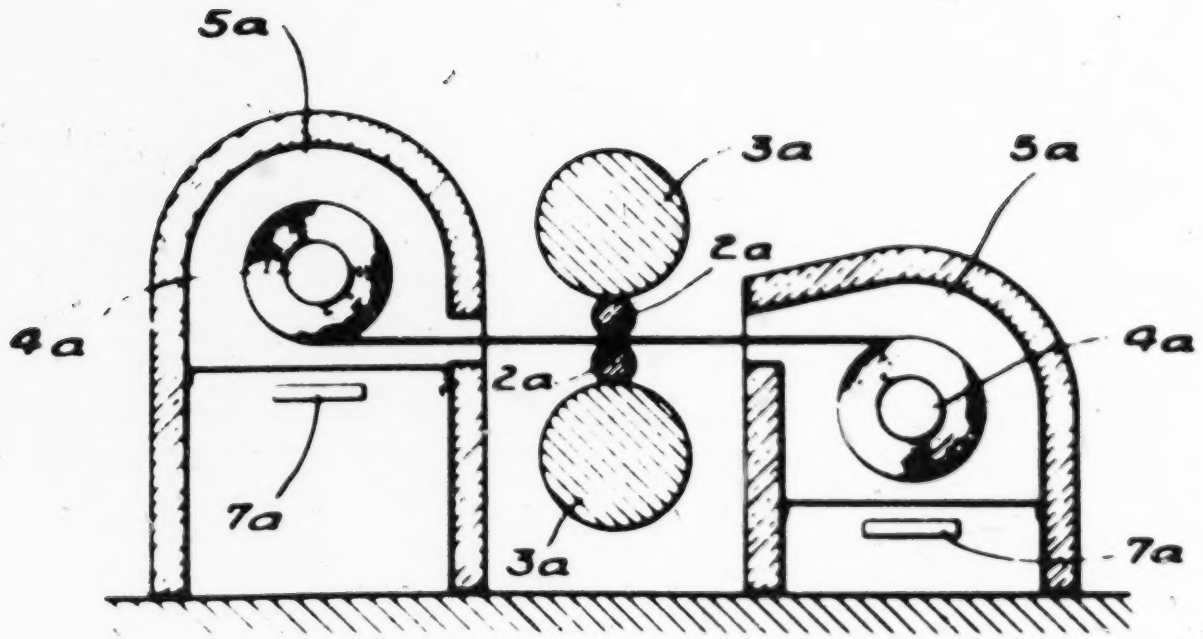
Fig. 4.



May 10, 1932. A P STECKEL 1,857,670

ROLLING METAL STRIP

Filed June 15 1927



July 18, 1933. R. M. KEENEY ET AL 1,918,968

ROLLING MILL

Filed Jan. 12, 1928

FIG. 1.

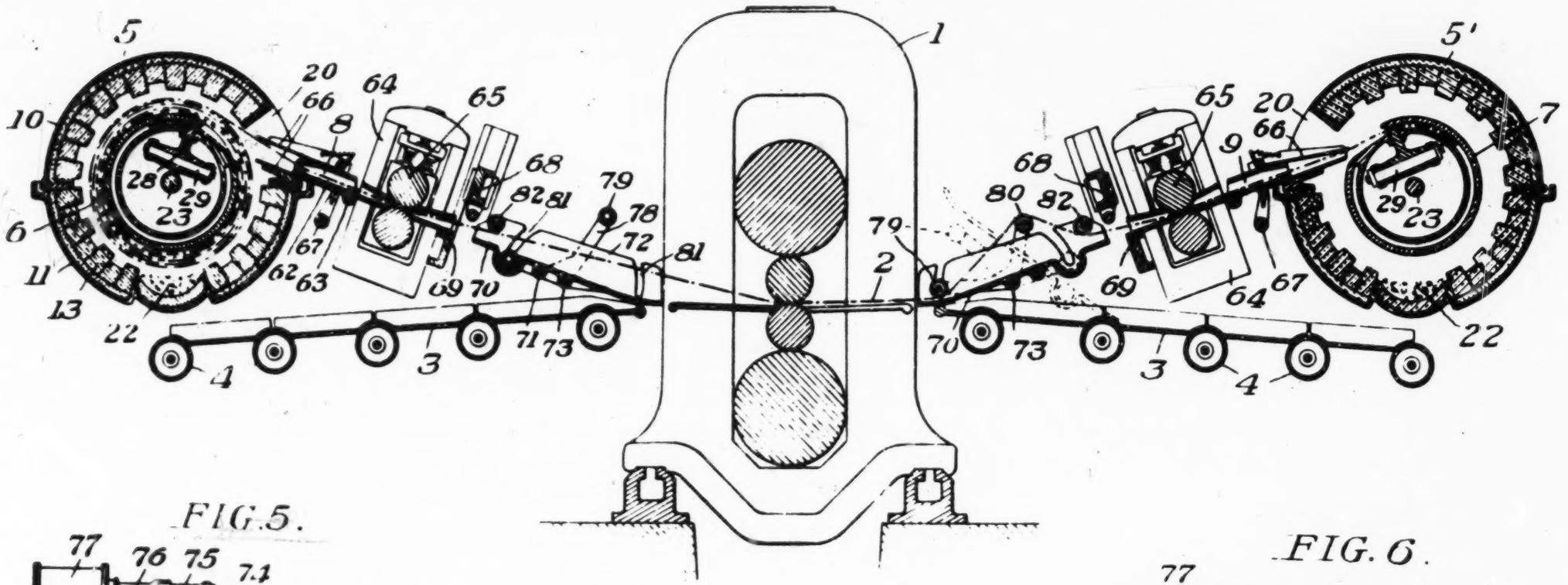


FIG. 5.

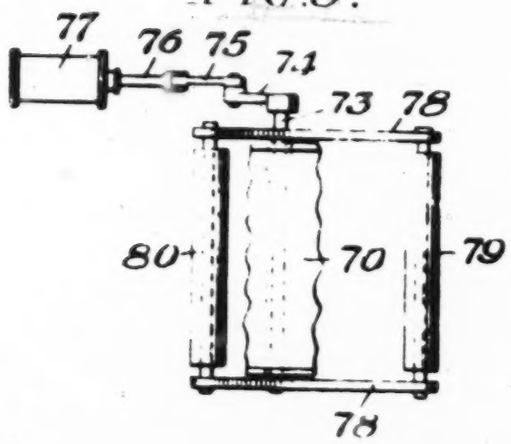
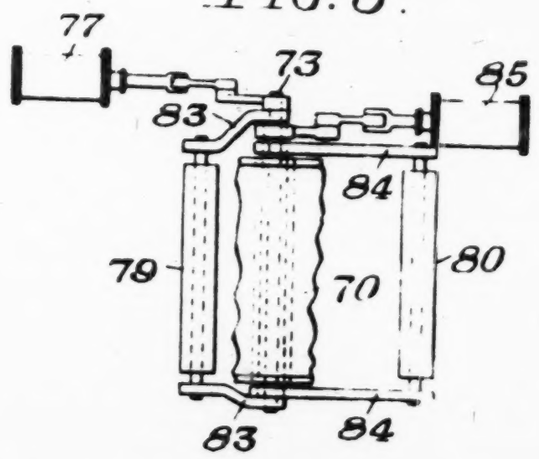


FIG. 6.

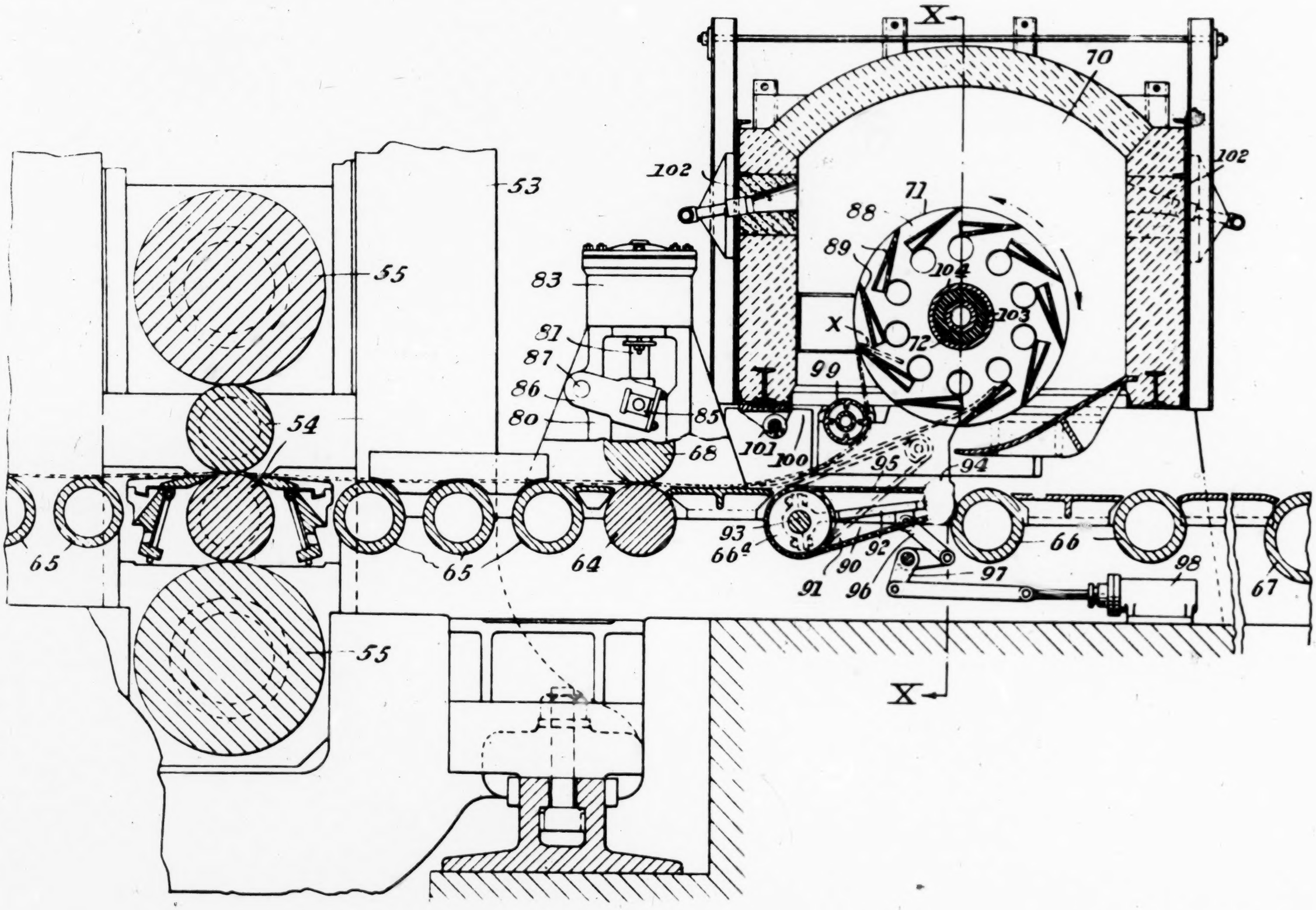


Oct. 16, 1934. A. P. STECKEL 1,977,214

METHOD AND APPARATUS FOR HOT ROLLING STRIP METAL

Filed May 4, 1931

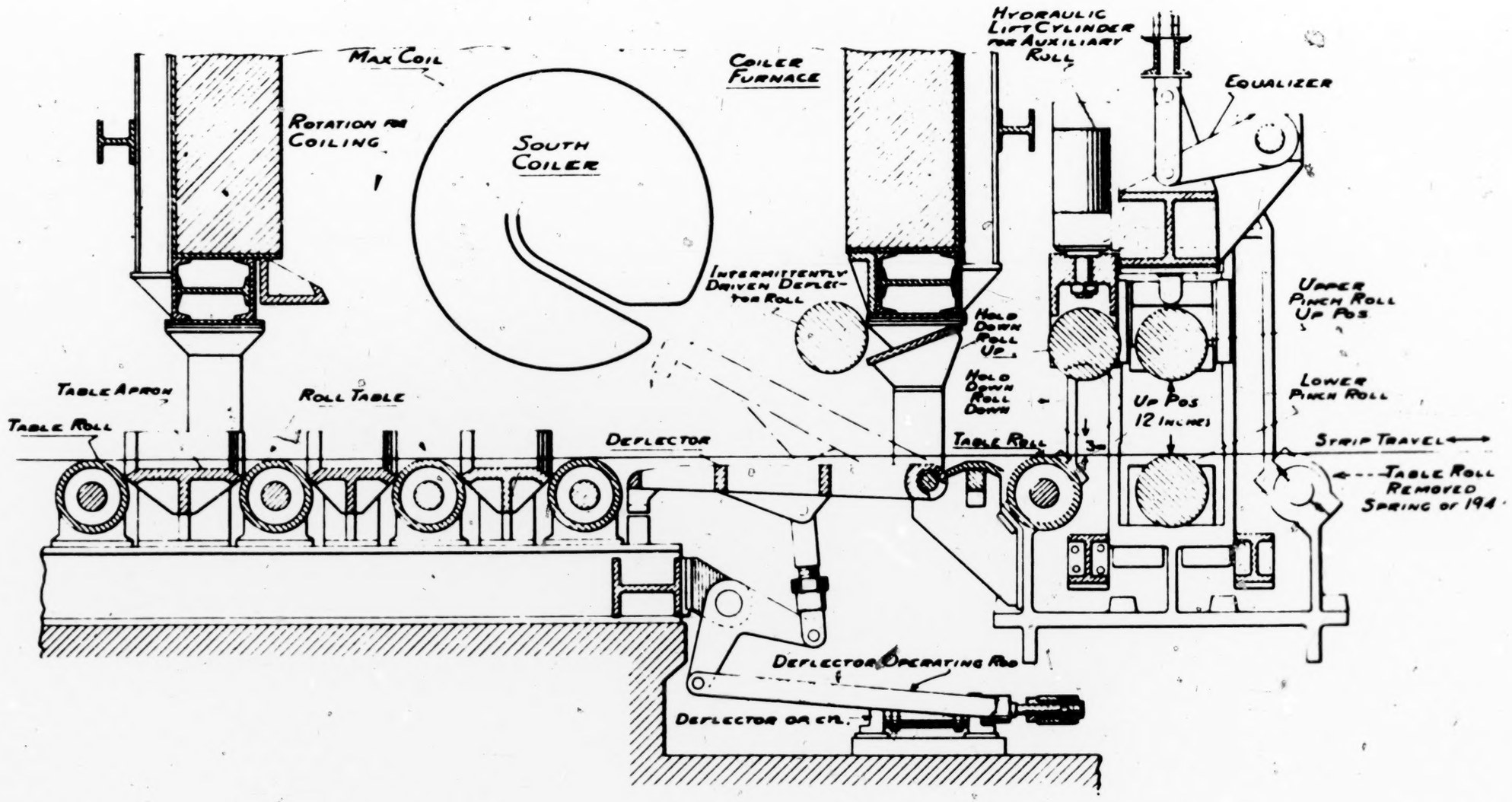
Fig. 4.



CRUCIBLE HOT STRIP MILL

VERTICAL SECTION AT PINCH ROLL & COILER

MODIFIED INSTALLATION



In my copending Patent 2,072,122, I have described and claimed a mill which is an improvement over those of the types shown in United States patents to Keeney et al. No. 1,918,968 and Steckel No. 1,977,214, including guides on both sides of the mill which, while operating on the principle described and claimed in the first mentioned copending application represent a structural improvement over the latter. Beyond the guides, pinch-rolls are disposed and coiling reels are mounted within heating furnaces, in the general manner shown in the patents referred to. In accordance with the present invention, however, I utilize the pinch-rolls only while starting the leading end of a breakdown through the mill and into the coiling reel on the opposite side, the pinch-rolls being thereafter retracted, freeing the strip between the mill and the reel. I then apply sufficient torque to the shaft of the winding reel to tension the portion of the breakdown between the reel and the mill. I also apply a back tension to the portion of the breakdown between the mill and the unwinding reel thereby exerting a retarding torque on the shaft of the latter. By thus tensioning the breakdown, I am able to form a tight coil on the winding reel, thus eliminating "skidding" and preventing cambering of the product during the later rolling passes.

* * * * *

These shafts are normally driven from extensions 50 of the shaft of one of the rolls 51 of the table 19. The rolls of the table are driven from a line shaft 52 through the usual bevel gears by a reversing motor, not shown. Between the shaft extensions 50 and the shafts 48 are positioned friction clutches 53 and jaw clutches 54 having operating levers 55.

* * * * *

The rolls 63 and 65 may be driven and when the former is lowered into engagement with the latter, they serve as pinch rolls to feed the strip toward the mill from the coiler 21. When the strip has been started through the mill and engaged the coiler on the opposite side thereof, the chucks 64 are preferably raised and the rolls 63, 64 and 66 lifted off the strip.

* * * * *

The cylinders 82 on the exit side of the mill thus operate to raise the associated pinch roll from the strip. The strip is thus free between the winding and unwinding coilers, except where engaged by the mill.

* * * * *

As soon as the leading end of the breakdown has been engaged by the coiling reel, and the pinch rolls retracted, I cause the motor 21*a* driving the coiling reel to exert thereon a torque sufficient to impart tension to the breakdown between the coiling reel and the mill. At the same time, I operate the motor 21*a* connected to the unwinding reel as a generator, to impart a back tension to the portion of the breakdown between the uncoiling reel and the mill. The torques exerted by the motor and generator are preferably maintained constant by any convenient means such as current regulators effective to maintain constant currents through the armatures of the motor and generator. The relationship of the regulators to the motor and generator is reversed on reversal of the mill, the regulator for the coiling-reel motor, obviously, being set for a greater current than the regulator connected to the uncoiling-reel generator.

By this provision, I tension the breakdown on the exit side of the mill between the mill and coiling-reel. On the entrance side, the breakdown is tensioned between the mill and the uncoiling-reel.

* * * * *

The automatic control of the pinch rolls on both sides of the mill insures that the strip will be advanced properly into the mill and, on emerging therefrom, into the coiler, whereupon the pinch rolls will be lifted out of the way when there is no further need for them.

* * * * *

4. In a method of converting a slab or ingot into strip, the steps including passing a slab back and forth in the flat between reducing rolls to form a breakdown, passing the breakdown back and forth between reducing rolls to form a strip, winding the breakdown on a coiling reel between passes through the rolls, bending the breakdown about a guide roll, and driving said guide roll to prevent frictional drag on the breakdown.

* * * * *

6. In a method of rolling strip, the steps including passing a breakdown, heated to plastic condition, back and forth between reducing rolls, uncoiling it on one side and coiling it on the opposite side of the rolls, passing an end of the breakdown entirely through the rolls, frictionally gripping said end to feed it back through the rolls, freeing that portion of the breakdown between the mill and the point of coiling, and tensioning such portion uniformly throughout.

7. In a method of making strip by passing a breakdown, heated to plastic condition, through reducing rolls, coiling the strip on the exit side, uncoiling it from a previously formed coil on the entrance side of the rolls, gripping the strip at points between the rolls and points of coiling only long enough at the beginning of each pass to thread the end of the breakdown through the rolls and start coiling thereof on the exit side, and then freeing the breakdown between the rolls and the points of coiling, while continuing to pass the strip through the mill in the same direction.

8. The method defined by claim 7 characterized by tensioning the portion of the breakdown between the rolls and the point of coiling uniformly throughout to cause the breakdown to coil straight and true.

Metal strip is now being rolled in continuous mills, but these mills are so large and occupy so much space that a very heavy capital outlay is required. The operating cost of the continuous mill is high because of the large amount of power required.

* * * * *

Coilers 4*a* are provided on either side of the mill, these being arranged to reel or to pay out material depending on which way the mill is running. Each coiler is motor driven and may be operated at such a rate as to maintain the delivered strip under tension.

* * * * *

2. The method of rolling metal strip which includes coiling a strip of hot metal in a heating chamber, uncoiling the same and feeding it from the chamber through a roll pass and to another heated chamber, coiling the strip therein in a direction opposite to that in which it was first coiled, periodically reversing the direction of rolling, and maintaining the metal under tension between the rolling thereof and the coiling thereof.

Figures 5 and 6 show alternative means for maintaining tension upon the strip.

* * * * *

To act as a drag upon the reel during unwinding we provide a band-brake 61 of common form for the shaft 23, having its free end counterweighted, so as to operate only when the shaft is turning in the unwinding direction. This brake is shown in Figures 2 and 3.

* * * * *

Tension is maintained yieldingly upon the looped strip, as shown in Figure 1, by means of the fluid-pressure cylinders, and the size of the loop aids the operator in adjusting the speed of rotation of the reel in the coiler to the speed of the reducing rolls.

* * * * *

In operation, assuming that the table 3 at the right-hand side of Figure 1 leads from the roughing mill, the roughed-down strip will be carried on this table into and through the initial pass between the reducing rolls 1, which also act to feed the strip up the chute at the left and between the pinch-rolls, which are being driven at that time and which feed the strip on into the coiler, the guide 62, 66 being in advanced position to direct the leading end of the strip into the slot 25 in the reel. As soon as the leading end of the strip enters the slot 25 it is locked by the bar 28, and the coiler-motor is started and the strip is wound on the reel, the pinch-roll motor being stopped and the driving-shaft disconnected by opening of its magnetic clutch, so that during the winding operation the pinch-rolls act as idle guide rollers.

* * * * *

During this reducing operation the pinch-rolls at the left turn idly, and the reducing rolls unwind the strip, the unwinding speed of the reel 6 being controlled by the drag-brake 61.

* * * * *

In the introductory part of this specification we have described this invention as particularly applicable to the hot rolling of iron or steel strips or strip sheets of light gauge and of great length. Heretofore in the art the term "strip" has been used to designate a long, thin piece of metal which is comparatively narrow, say of a maximum width of sixteen inches. Our invention is not limited to the manufacture of such pieces, but it is the intention to cover in the appended claims the manufacture of long, thin pieces of metal of any practicable width, and designated by us generally (whether narrow or wide) as thin metal strips.

The pinch rolls operate to maintain the material under tension and this is highly desirable. It insures straightness of the product and materially simplifies the handling. The pinch rolls on the exit side will be arranged to exert a forward pull on the material, and those on the entering side will be arranged to impart a drag thereto. This causes the material to issue straight. If there are any slight irregularities due to over-rolling at one point or another across the width of the strip, such irregularities will be largely or entirely removed.

EXHIBIT D-21

YEAR BOOK

OF THE

American Iron and Steel Institute

1927

MAY MEETING - - - - - - - - NEW YORK
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THE EVOLUTION OF THE WIDE STRIP MILL

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The outstanding achievement of the present decade, in the history of the rolling mill, is the development in the art of rolling wide, thin sections, as exemplified by the wide strip mill and the continuous sheet mill.

The rolling of wide, thin sections has developed along two distinct and originally widely separated lines.

First: the rolling of strip, characterized by limitations in width and gage, rather than in length.

Second: the rolling of sheets, characterized by limitations in length, rather than in width and gage.

In 1924 strip was obtainable in widths up to 24 inches and in lengths as long as were demanded. Sheets were obtainable in widths as wide as were demanded (to about 54 inches) but were limited in length.

Strip was produced from billets and slabs, and in units from 100 pounds up to 2000 pounds in weight, and was finished at delivery speeds up to 1000 feet per minute.

Sheets were produced from sheet bars, and in units from 12 pounds up to 70 pounds in weight, and were finished at delivery speeds of about 240 feet per minute.

Strips were always rolled single, while sheets were generally rolled in "packs."

In the year 1924 a sheet mill was placed in operation that produced sheets by a continuous process, in widths up to 45 inches and in lengths up to 30 feet. In 1927 a product was placed on the market, in widths up to 36 inches, having characteristics of both strips and sheets, but without the previously existing dimentional limitations of either. This new product approximates to strips in length, to sheets in width, and to both, in gage and physical characteristics. For the purposes of this paper it will be designated by the term

as well as blue annealed sheets, in widths up to 48 inches and in gages from 6 to 16 inclusive, in addition to the rough sheets produced for further reduction to lighter gages in the sheet mill.

The production of the Ashland Plant was over 24,000 tons in both May and June of the present year, and this was limited, not by the capacity of the mill, but by the open-hearth production. Two more furnaces are now being added and it is not expected that this will give a production in excess of the capacity of the mill to handle it. Of the 24,000 tons produced over 10,000 tons was in sheets of 16 gage and lighter that went into the highest grade of automobile body and crown fender stock.

The Butler 42-inch Mill

In 1924 5 plans were laid for the commercial production of broad strips in widths up to 36 inches and 18 gage and heavier.

The steel plant at Butler, Pa., known as the Forged Steel Wheel Company, was consolidated with the allied interest, the Columbia Steel Company, of Elyria, Ohio, the consolidation taking the name of the latter company. On August 1, 1927, the ownership of the combined companies passed into the hands of the American Rolling Mill Company.

The construction of the mill was commenced early in 1926, the buildings housing an 18-inch and an 18-inch-12-inch 9-inch merchant mill being utilized to house the new mill. Two producer gas fired, continuous heating furnaces, 14 feet wide inside by 55 feet long, belonging to the 18-inch merchant mill were utilized to heat the slabs for the new mill. Slabs were produced on the universal slabbing mill belonging to the steel plant of the Forged Steel Wheel Company, and ranged in size from 12 inches to 36 inches in width, by $2\frac{1}{2}$ inches to 5 inches in thickness, and from 6 feet to 12 feet 6 inches in length.

The slabbing mill consists of a two-high, reversing, universal roughing stand with vertical rolls on both sides. The horizontal rolls are 27 inches by 48 inches and the

vertical rolls are so arranged as to go back into the housings and give a maximum opening of 37 inches thus utilizing nearly the full length of the body of the horizontal rolls.

The finishing mill, located 165 feet away from the universal mill, consists of four stands of 16½-inch and 40-inch by 42-inch four-high rolls, equipped with roller bearings, and spaced on 22-foot centers, with loopers between.

The universal roughing stand is driven by a 5000 H.P., reversing, D.C. motor, having a speed range from 0 to 150 R.P.M., directly connected to the mill. The four finishing mills are each driven by a 2000 H.P., adjustable speed, D.C. motor connected to the mill through gear reduction. Total H.P., 13,000.

PASS TABLE

Pass No.	Type	Rolls Diameter	Rolls Length	R.P.M.	Distance to next pass	Motor H.P.	Motor R.P.M.
1	universal						
2	universal						
3	universal	27"	48"	0 to 150	165' 0"	5000	0 to 150
4	universal						
5*	universal						
6	flat	16½" 32"	42"	55.4 to 110.8	22' 0"	2000	200 to 400
7	flat	16½" 32"	42"	76.7 to 153.4	22' 0"	2000	200 to 400
8	flat	16½" 32"	42"	98.4 to 192.8	22' 0"	2000	200 to 400
9	flat	16½" 32"	42"	107.4 to 214.8		2000	200 to 400

* The slab is given a varying number of passes in the roughing stand.

The heated slab, after leaving the furnace, passes through a scale breaker consisting of five staggered corrugated rolls which serves to break up the furnace scale. It passes to a manipulator which turns it over and knocks off the loosened scale, and then passes to the mill.

The slab receives from 5 to 7 passes in the universal stand where it is reduced to a thickness of from ¼ inch up to ½ inch, according to the required thickness of the finished strip. On leaving the universal mill it passes direct to the finishing mill, receiving one pass in each stand.

From the last stand of the finishing mill, the piece travels down a roller table to a coiler where it is coiled up for further operation. Heavy gage material may also be cut to length

by a shear in the line of the roller table without passing through the coiler.

This mill represented the first application of the four-high mill to the hot rolling of strip, and this, together with the high finishing speed, was the means relied upon to secure the thin gage and wide width desired.

The mill started operation in November, 1926 and has produced strips from 12 inches to 36 inches in width and from 3/16 inch down to .058 inch in gage. The mill has rolled as much as 1000 tons in 24 hours and in March, 1927 produced over 14,000 tons, and in June, 1927 over 16,000 tons of hot rolled material.

The hot strip sheet mill was designed to produce gages as light as No. 16 only. When lighter gages are required they are produced by cold rolling.

For this purpose there are six four-high cold mills located in a parallel bay of the building, the intermediate bay being occupied by the continuous pickling and annealing equipment. The coils of hot finished material are transferred to this latter bay where they are passed through a continuous pickler, being uncoiled just before entering the pickling bath, the front end of each coil being welded to the back end of the preceding coil in such manner as to make the process continuous. After pickling, the strip is coiled up again and the coils divided by shearing out the welded portion. The pickled coils are then transferred to the cold mill building where they receive the required number of passes to reduce them to the gage desired. The coils are then transferred back to the central bay where they are annealed in a continuous furnace to remove the effects of the cold rolling. After annealing it may or may not receive a further reduction as determined by the physical properties desired.

The Development of the Four-High Mill

At this time, a word or two regarding the development of the four-high mill will not be out of place. The earliest application of the backing-roll principle, as applied to the rolling mill, of which we have any record, is in 1864 when

Note

Text ends at this point,
without explanation or notice.